SCIENCE

14 February 1958

Volume 127, Number 3294

UNIVERS . . .
OF MICHIGAN
FEB 19 1958
PERIODICAL
READING ROOM

Editorial

Strength Through Union 313

Articles

Self-Stimulation of the Brain: *J. Olds* 315

Possible Sources of a Lunar Atmosphere: *W. F. Edwards* and *L. B. Borst* 325

Louis Pillemer, Immunochemist: *E. E. Ecker* 328

News of Science

News Articles and Briefs; Scientists in the News; Recent Deaths 330

Reports

Dissimilation of Alfalfa Saponins by Rumen Bacteria: *J. Gutierrez, R. E. Davis, I. L. Lindahl* 335

Spectral Changes Accompanying Binding of Acridine Orange by Polyadenylic Acid: *R. F. Steiner* and *R. F. Beers, Jr.* 335

Use of Mononitrophenols Containing Halogens as Selective Sea Lamprey Larvicides: *V. C. Applegate, J. H. Howell, M. A. Smith* 336

Convenient *p*H Stat Reaction Vessel for Small Volumes: *G. H. Dixon* and *R. D. Wade* 338

Correlation of Potassium-40 Concentration and Fat-Free Lean Content of Hams: *R. Kulwich, L. Feinstein, E. C. Anderson* 338

Composition of Cardiolipin: *F. A. H. Rice* 339

Protective Effect of a Colchicine Derivative in Mice Exposed to X-radiation: *W. W. Smith* 340

Localization of Generator Structures of Electric Activity in a Pacinian Corpuscle: *W. R. Loewenstein* and *R. Rathkamp* 341

In vitro Culture of Excised Ovules of *Papaver somniferum: N. Maheshwari* 342

Book Reviews

Religion Without Revelation; The Carbohydrates; Morphological Astronomy; Recent Progress in Hormone Research; The American Economy; New Books; Miscellaneous Publications 343

Meetings and Societies

Origin of Life; Forthcoming Events 346

Letters 349

Equipment News 353

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A New Milestone in High Resolution Spectroscopy

60 MEGACYCLE NMR

Nuclear Magnetic Resonance

Imagine a High Resolution NMR Spectrometer operating above 14,000 gauss without sacrifice of field uniformity! A breakthrough in Varian's research and development laboratories did the trick. This seemingly unattainable field for proton studies is more than *twice* the strength announced elsewhere, and even exceeds Varian's previous standard by one-and-one-half times.

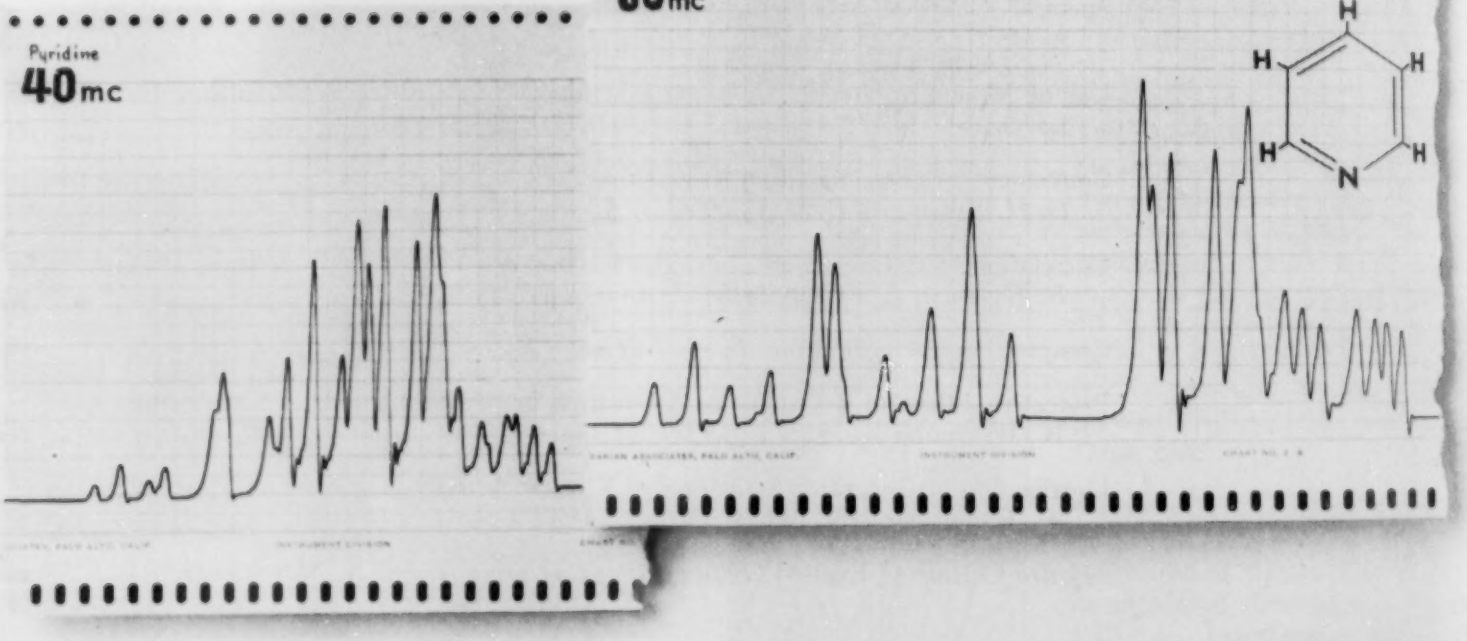
Why does the chemist seek the highest feasible magnetic field strength? Because:

(a) NMR chemical shifts increase linearly with H_0,
(b) signal voltages go up as H_0^2,
(c) confusing second-order splittings decrease as $1/H_0$, thereby concentrating precious spectral intensity in the minimum number of meaningful peaks.

Thus, with the field frontier rolled back, the chemist can study smaller quantities and more complex compounds. In addition, the new electromagnet is designed for high-homogeneity operation at all fields up to the 14,100 gauss maximum. Advantages: ready adaptability to studies of spectral field-dependence and to nuclei other than protons.

The new 60 mc. Spectrometer incorporates r-f circuit refinements which further enhance stability and sensitivity. In keeping with Varian's long-standing policy of reasonable compatibility, existing NMR Spectrometers can be converted to 60 mc. operation with simultaneous retention of their present capabilities.

(Note: This announcement has replaced our regular NMR and EPR-at-work Series in this one issue. The series will resume hereafter.)



INTERPRETATION: The NMR spectra of the β and γ protons in pyridine are shown at both 40 and 60 mc. above. The most striking feature of the comparison is the clear separation at 60 mc. of the two proton types, the group of lines at the left being due to the γ proton and those at the right arising from the β protons. The 40 mc. spectrum is hopelessly run together and suffers from severe distortion of intensities and line positions from those predicted by a simple first-order treatment. At still lower radio frequencies the pattern would degenerate to a meaningless jumble of lines.

Write today for full information on the new 60-megacycle Varian NMR Spectrometer, available both as a straight High Resolution instrument, and as a Dual Purpose unit.

VARIAN associates

INSTRUMENT DIVISION

611 Hansen Way, Palo Alto 18, California

14 February 1958, Volume 127, Number 3294

SCIENCE

AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE

Board of Directors

WALLACE R. BRODE, *President*
PAUL E. KLOPSTEG, *President Elect*
LAURENCE H. SNYDER, *Retiring President*
PAUL M. GROSS
GEORGE R. HARRISON
CHAUNCEY D. LEAKE
MARGARET MEAD
THOMAS PARK
MINA REES
WILLIAM W. RUBEY
ALAN T. WATERMAN
PAUL A. SCHERER, *Treasurer*
DAEL WOLFLE, *Executive Officer*

DAEL WOLFLE, *Executive Officer*
GRAHAM DUSHANE, *Editor*
JOSEPH TURNER, *Assistant Editor*
ROBERT V. ORMES, *Assistant Editor*

Editorial Board

WALLACE R. BRODE — EDWIN M. LERNER
BENTLEY GLASS — WILLIAM L. STRAUS, JR.
KARL LARK-HOROVITZ — EDWARD L. TATUM

Editorial Staff

MARY L. CRABILL, SARAH S. DEES, LUCILLE GUINARD, NANCY S. HAMILTON, OLIVER W. HEATWOLE, YUKIE KOZAI, ELLEN E. MURPHY, BETHSABE PEDERSEN, MADELINE SCHNEIDER, JACQUELYN VOLLMER, MARIA A. WOLSAK

EARL J. SCHERAGO, *Advertising Representative*

SCIENCE, founded in 1880, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879.

SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. **Single copies,** 35¢. Cable address: Advancesci, Washington.

Strength Through Union

One of the most serious, if not one of the most spectacular, tasks for science is that of keeping its literature accessible. In the more leisurely days of the past the problem of communicating results was met largely through the efforts of scientists themselves: they organized abstracting and indexing services for their particular fields either on their own or with some foundation or governmental support.

But with the growth of science the task has become more formidable. For example, *Chemical Abstracts*, which covers the world literature in chemistry, abstracts about 100,000 articles per year from about 7500 journals, 2000 books, and the patents of 22 countries. The future holds no hope for a diminution of effort. The rate of publication in chemistry has doubled every 8½ years during this century and there is no sign of leveling off yet. The volume of publication is increasing in other branches of science too. The total job to be done can be appreciated by considering that some 50,000 scientific journals currently publish about 2 million articles per year.

This is clearly the time for a reappraisal of our methods for handling scientific information. Among those who have considered the problems involved there is general agreement that we need a clearinghouse and a coordination center for abstracting, indexing, retrieving and translating. Some would have us establish a counterpart of the Soviet All Union Institute of Scientific and Technical Information, which would be entirely under Government control. Others would prefer that the entire program be operated by a private corporation under Government contract.

Still others, and we are among them, favor a combination of private and governmental effort. Two recent events have made it possible to envisage such an operation. The Office of Technical Services in the Department of Commerce, working in cooperation with the National Science Foundation, is enlarging the scope of its activities so that it may function as a center for information about foreign translations made by either governmental or nongovernmental agencies, for indexing and cataloging, for arranging for translating when translations are not available, and for other related purposes.

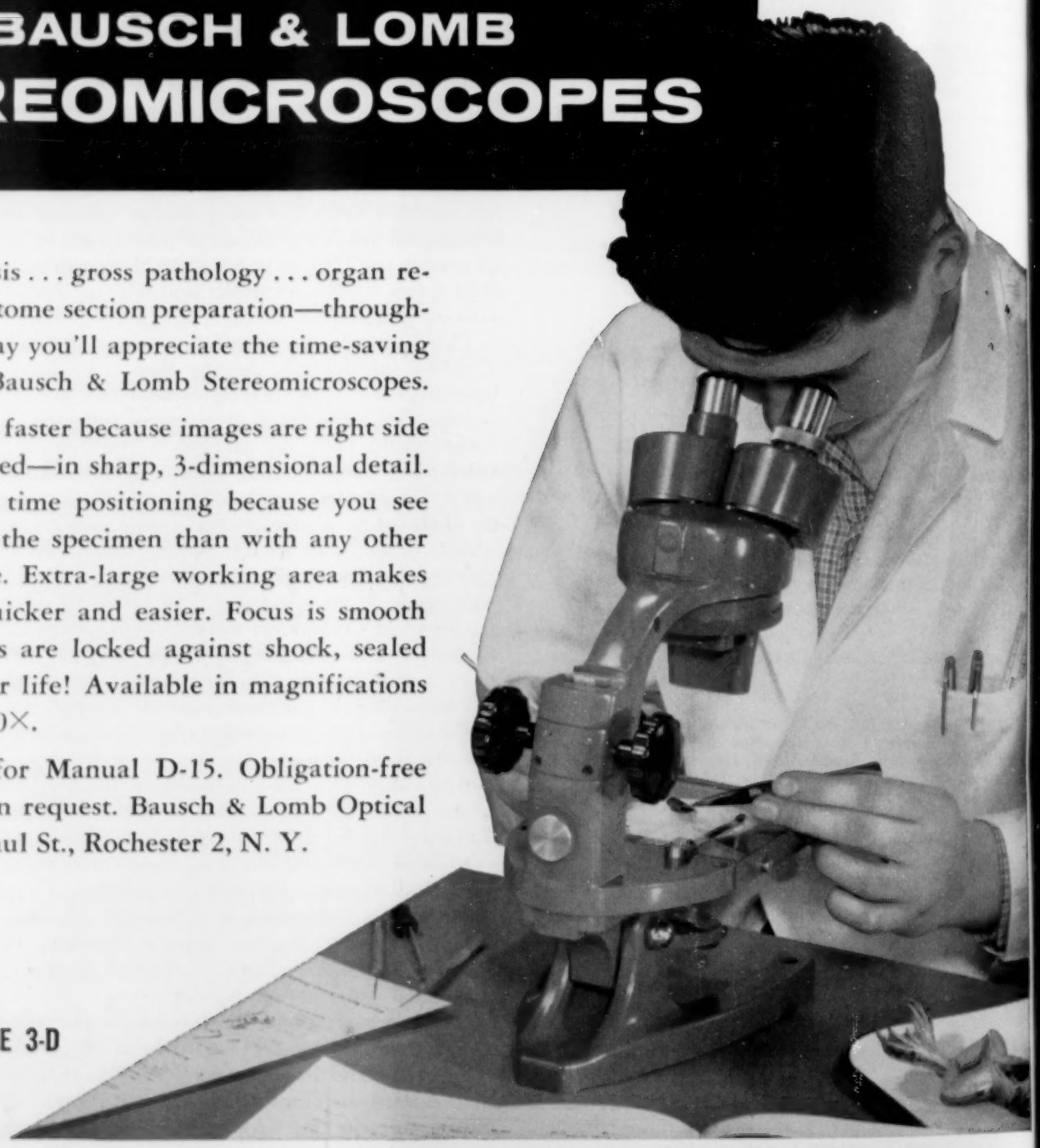
The other event is a consequence of a conference of the following 14 organizations in Philadelphia at the end of January: Applied Mechanics Reviews, Bibliography of Agriculture, Bibliography of Technical Reports (Office of Technical Services, Dept. of Commerce), Biological Abstracts, Chemical Abstracts, Current List of Medical Literature, Engineering Index, International Aeronautical Abstracts, Mathematical Reviews, Meteorological Abstracts, Nuclear Science Abstracts, Psychological Abstracts, Review of Metal Literature, Technical Abstract Bulletin (Armed Services Technical Information Agency).

These organizations, which annually abstract or index more than 400,000 articles and books, decided to form the National Federation of Science Abstracting and Indexing Services. This federation is in itself an important step toward the elimination of duplication of effort and toward the setting up of uniform standards in classification, terminology, abbreviations, and transliteration. But its main significance lies in its potential function as a nongovernmental agency prepared to work in harmony with the central clearinghouse in the Office of Technical Services and eligible to receive private or Federal support for carrying out its important mission.—G.DuS.

Speed Lab Routine

with Vivid 3-D Views

BAUSCH & LOMB STEREOMICROSCOPES

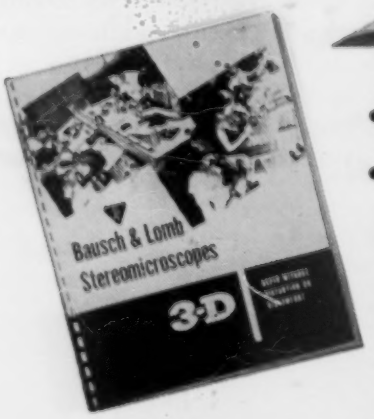


Specimen analysis . . . gross pathology . . . organ removal for microtome section preparation—throughout your busy day you'll appreciate the time-saving advantages of Bausch & Lomb Stereomicroscopes.

Interpretation is faster because images are right side up and unreversed—in sharp, 3-dimensional detail. You spend less time positioning because you see clearly more of the specimen than with any other stereomicroscope. Extra-large working area makes manipulation quicker and easier. Focus is smooth and easy. Prisms are locked against shock, sealed against dust—for life! Available in magnifications from 6.6× to 150×.

WRITE today for Manual D-15. Obligation-free demonstration on request. Bausch & Lomb Optical Co., 64226 St. Paul St., Rochester 2, N. Y.

FREE! EXCLUSIVE 3-D MICRO-VISION BOOK



- See actual stereo views!
- Fit exact model to specific laboratory needs with unique Selector-Chart.

BAUSCH & LOMB

SINCE B&L 1853

America's only complete optical source . . . from glass to finished product.

14 February 1958, Volume 127, Number 3294

SCIENCE

Self-Stimulation of the Brain

Its Use To Study Local Effects of Hunger, Sex, and Drugs

James Olds

This article reviews experiments which have led to the discovery and analysis of localized systems in the brain where electric stimulation has positive and negative motivational effects (*1*). Basically, the experimental animal in these studies is rewarded or punished by a brain shock. The site of electric stimulation determines the motivational effect.

The studies are important primarily as a beginning step toward filling the large gap which has existed between neurophysiological techniques and an understanding of complex psychological processes. Among other things, they carry the enterprise of brain mapping into the realm of clearly defined motivational functions; this by itself correlates an orderly array of integrative psychological mechanisms with an orderly array of anatomical points in the brain. Furthermore, these studies perform a unification long considered technically impossible between electrophysiological, independent variables and standard, behavioral, dependent variables to produce smooth interaction curves relating the two.

For psychologists, these experiments help to clarify the basic notions of reward and punishment. Reward and punishment, it is agreed, determine which behaviors will predominate in an organism's repertory and which will be erased from it. Rewarded responses are repeated more frequently than would be expected by chance; punished ones are repeated with less frequency. This is obvious.

Less self-evident is the thesis of the classical theory of reward, according to which reward is interpreted as being the falling phase of the same massive stimulation which at high levels constitutes punishment. This thesis is greatly weakened by the work outlined in this article; however, it has held sway for such a long time in psychology and conditions so many basic attitudes that it will certainly form a foundation stone for the new theories which replace it.

Drive and punishment are synonymous, according to this theory, and a reward is held to be fundamentally nothing more than the reduction of a drive. Physiological conditions which are inimical to survival, such as food deficiencies or tissue damage, cause massive receptor discharge into the central nervous system. This discharge is held to be the drive, and it is held to be reflected in behavioral activation. The latter is a nonselective function of the massive drive stimulation, energizing adaptive and maladaptive responses equally. The drive stimulation, however, also has a selective function by which it combines with other cue stimuli to select those responses which have repaired this particular physiological deficit in the past.

The response actually selected by the combination of drive and cue stimuli is determined entirely by structural cue-response connections whose strength has been determined by prior learning. More specifically, a group of cues actually selects the response which was previously followed by drive reduction in their presence. The drive reduction, on previous occasions, caused a rewarding or positive reinforcing effect which somehow increased the causal connection between these stimuli and this particular response.

The hedonistic view that behavior is pulled forward by pleasure as well as pushed forward by pain is rejected in this classical theory for the more parsimonious notion that pain supplies the push and that learning based on pain reduction supplies the direction.

The work reported in this article clearly shows one implication of the drive-reduction theory to be incorrect, for massive inputs to certain parts of the central nervous system are shown to have rewarding effects. Further, by showing that there are anatomically separate mechanisms for reward and punishment in the brain, it points directly to a physiological basis for the motivational dualism suggested in the hedonistic theory.

In fact, it appears that the area producing rewarding effects, upon electric stimulation, is far larger than the area producing punishment. In one early experiment, 76 electrodes were implanted in the brains of rats in an attempt to get a random sampling of midbrain and forebrain points. It was found that stimulation at 47 of these points had motivational effects. Stimulation at 36 of these motivational points produced approach behavior—that is, the rats stimulated themselves repeatedly by means of the technique described below; at only 11 points did stimulation produce avoidance behavior (*2*).

Basic Studies

Method. The method of self-stimulation (*3*) is modeled in part after the chronic implantation technique of W. R. Hess (*4*) and in part after the box technique of B. F. Skinner (*5*). The former developed a technique for implanting electrodes permanently in the brain; the

Dr. Olds, former member of the staff of the department of anatomy at the School of Medicine, University of California at Los Angeles, is now with the department of psychology at the University of Michigan, Ann Arbor.

technique allows stimulation in the freely behaving animal. The latter worked out a way to measure positive reinforcement—that is, reward—by arranging a situation in which the experimental animal could deliver the reward to itself by a very simple manipulation, and then counting the frequency of the manipulations. Self-stimulation combines these techniques by allowing animals to deliver shocks to specific points in their brains through chronically implanted electrodes.

Figure 1 shows the method used. When the rat stepped on a pedal, a shock was delivered to its brain. The rat

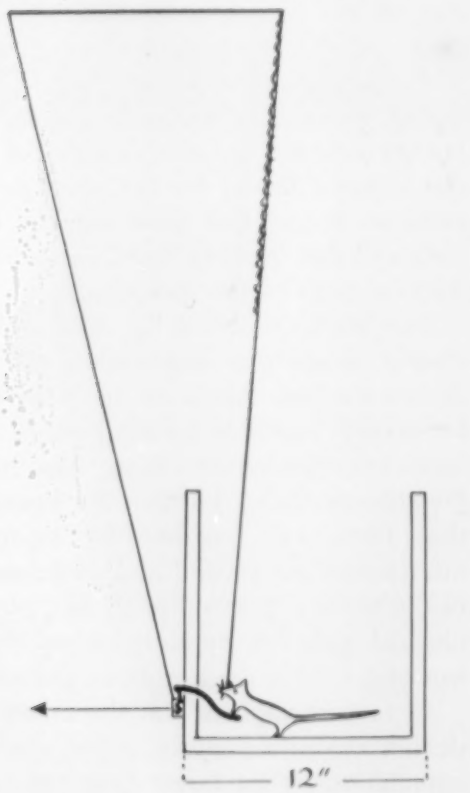


Fig. 1. Diagram of apparatus by means of which a rat delivers electric shocks to its own brain. When the rat steps on the pedal, the electric circuit is closed and current is transmitted to its brain by means of implanted electrodes.

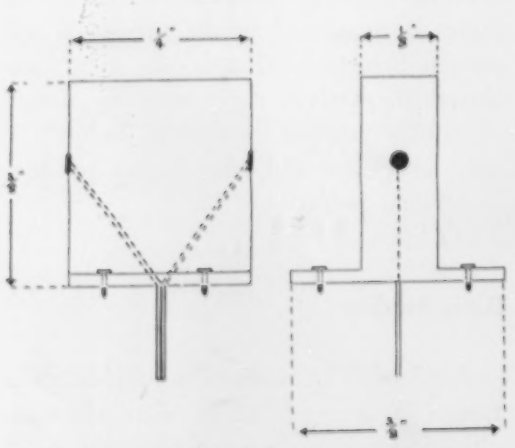


Fig. 2. Diagram of plastic electrode carrier, containing a pair of silver electrodes, which is screwed to skull of rat, with wires penetrating deep into the brain, as shown in Fig. 3.

never received any other reward for pressing the pedal, and the shock was never turned on except when the rat turned it on itself by stepping on the pedal.

In this box, animals invariably stepped on the pedal about 25 times during the first hour (although there was no rewarding electrical stimulation at all), because the pedal was so placed that it would be pressed when the animal looked out the only opening in the box. After the first hour there were about five responses or less per hour during hours in which no reward was produced. If the pedal-pressing produced a reward, the rate, even for the first hour, rose to 200 or more responses an hour; thus, "reward" was clearly discernible. If the pedal-pressing produced punishment, the rate dropped radically; there were only two or three responses during the total experimental procedure; thus, "punishment" was clearly discernible.

If the electrode was placed in the brain at a point at which maximum self-stimulation is produced, the rat, after its very first electric stimulation, began to search and pursue eagerly. Its response to the first shock was to sniff in all corners of the box and manipulate quickly the objects in its path until it stepped on the pedal a second time. After the rat had pressed the pedal a second or third time, it ceased to wander and began to respond at the rate of one or two pedal-presses per second. These animals learned to press the pedal within a minute or two.

Figure 2 shows, in schematic form, the plastic electrode carrier which was screwed to the skull and a pair of silver-wire electrodes implanted in the brain through a hole in the skull. The insulated wires, which were 0.01 inch in diameter, stimulated the brain only at their tips. The electrode apparently fired cells up to a distance of at least 0.5 millimeter from its tip. Figure 3 (top) is an x-ray photograph of an electrode in place in the brain of an intact animal; in Fig. 3 (bottom) the tip of the electrode track appears as a blackened area on the photomicrograph of a stained brain slice. In these experiments each brain was sectioned and stained after testing; all statements about localization are based on examination of this histological material.

The stimulus was a sine-wave shock at 60 cycles per second; the current ranged from 5 to 100 microamperes; the animal received a shock lasting for a maximum of 0.5 second. If the animal held the pedal down for less than 0.5

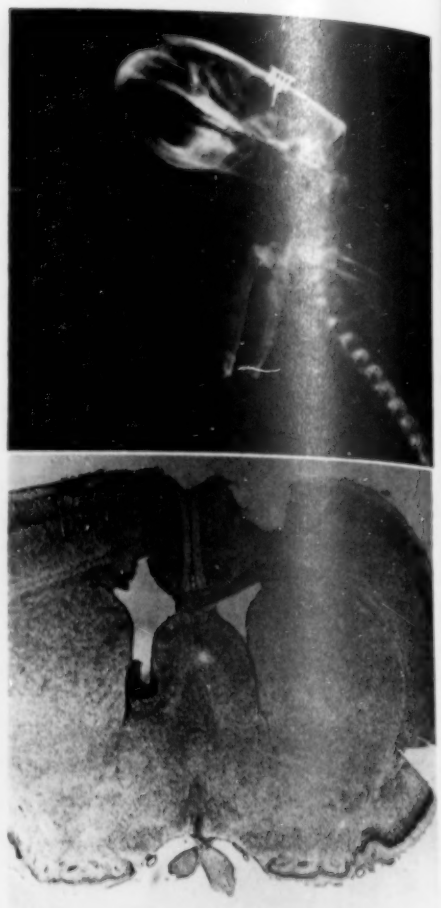


Fig. 3. (Top) X-ray photograph of an electrode (deepest shaft) in place in the brain of a rat. The four shorter shafts are screws which hold the electrode carrier to the skull. (Bottom) Photomicrograph of stained brain slice from a rat sacrificed at the end of a series of experiments. The tip of the electrode track appears as darkened area. Wires are insulated along their whole length and stimulate the brain only at the tip.

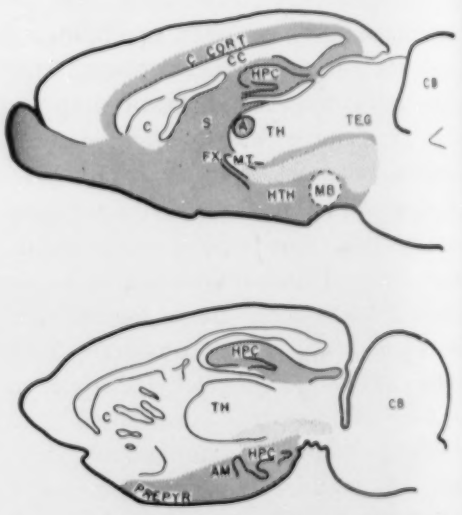


Fig. 4. Medial and lateral sagittal sections of the rat brain showing, by cross-hatching, the areas where electric stimulation causes approach behavior and, by stippling, the areas where electric stimulation causes avoidance. *A*, anterior thalamus; *AM*, amygdala; *C*, caudate nucleus; *CB*, cerebellum; *CC*, corpus callosum; *C CORT*, cingulate cortex; *FX*, fornix; *HPC*, hippocampus; *HTH*, hypothalamus; *MB*, mammillary bodies; *MT*, mammillothalamic tract; *PREPYR*, prepyriform cortex; *S*, septal area; *TEG*, tegmentum; *TH*, thalamus.

second, the current went off when it released the pedal. If it held the pedal down for longer than 0.5 second, the current went off automatically and the rat had to release the pedal and press it again to produce another shock.

Locus. Electric stimulation in most parts of the rhinencephalon, and in many parts of the hypothalamus and related structures (see cross-hatching, Fig. 4), produced the approach response (2). Stimulation in small areas in the midbrain and in certain adjacent parts of the thalamus and hypothalamus (see stippling, Fig. 4) produced the avoidance response. Such avoidance behavior was first demonstrated in the cat, by Delgado, Roberts, and Miller (6). In the rat, the area in which stimulation produced avoidance behavior was small compared with the area in which it produced approach behavior.

The rate of self-stimulation tended to diminish steadily as the site of stimulation was moved toward the cortex. Rates as high as 7000 per hour were achieved when electric stimulation was applied in the region of the interpeduncular nucleus of the tegmentum.

With electrodes placed in the posterior hypothalamus, just in front of the mammillary body, very high rates, in the range of 5000 per hour, occurred frequently. With electrodes placed in the anterior hypothalamus, rates ranged from 400 to 1100 per hour. With electrodes placed farther forward, in the preoptic and telencephalic areas, there was a second series of rates, ranging from quite high ones (about 3000 per hour) for the preoptic area to very low ones (about 200 per hour) for the anterior forebrain. The high rates obtained in the forebrain series were lower than the high ones of the hypothalamic series.

Thus, there was, for the hypothalamus, a decline of response rates as the electrode was moved forward. There was a similar trend for the telencephalic region, and the rates for the whole of the telencephalic region seemed to be lower than those for the whole of the hypothalamic region.

Electric current. Studies in which the level of electric current was varied (see Fig. 5) provide some basis for explaining these differences in rate of self-stimulation. The level of the shock was raised from 0 to 150 microamperes by steps of 10. Self-stimulation rates started at chance levels of about 4 to 40 responses per hour and remained at these chance levels at 0, and sometimes at 10, microamperes. Then, usually at 20 or 30 microamperes, but sometimes at 10 microamperes or less, a threshold was crossed and self-stimulation rates rose rapidly. As the current was raised further, the response rate showed a steady increase, undulated, or showed no further increase.

We assume that the cells and fibers excited by the electric stimulus obey the all-or-none principle and have relatively similar thresholds. If this is true, each increase in current brings cells at a greater radius from the tip of the electrode to threshold.

Thus, the steep asymptotic curves at the top of Fig. 5 indicate that stimula-

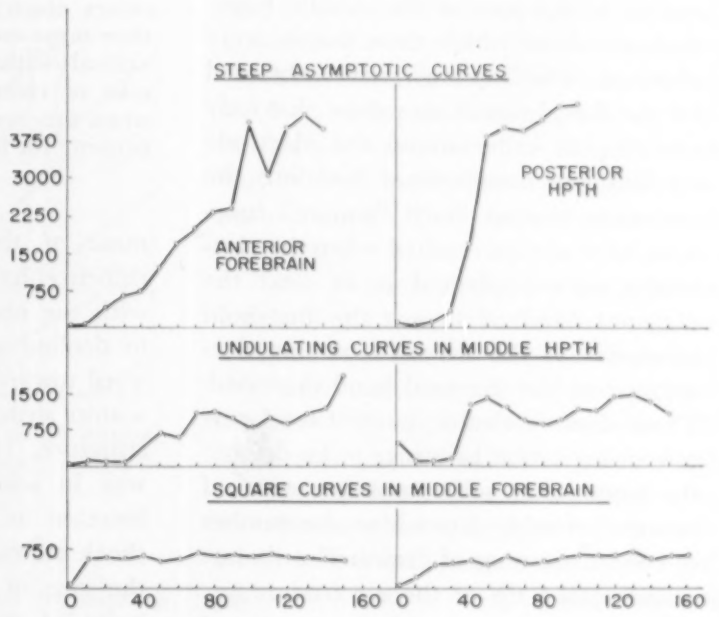


Fig. 5. Electric-current functions. The hourly self-stimulation rate (plotted along the ordinate) tends to rise as current (on the abscissa) increases from 0 to 160 microamperes in steps of 10. In the middle hypothalamus the curve shows a temporary decline when the electric field invades an area where electric stimulation has a negative motivational effect. In the middle forebrain there is an abrupt rise to 500 responses an hour and then no further increase, because there is a very small field in which positive motivational effects are obtained, surrounded by a larger neutral area.

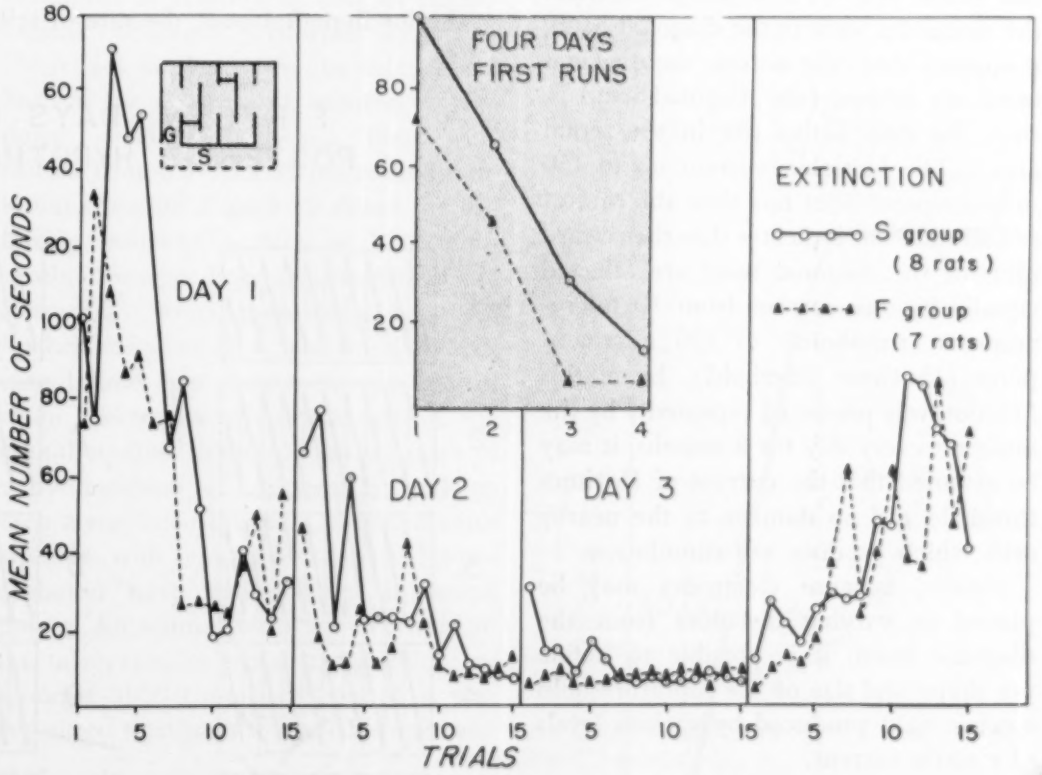


Fig. 6. Maze experiment. At the upper left is a maze. The animal runs from the start position *S*, through the maze, to the goal poistion *G*. At *G* it finds a pedal, steps on it, and stimulates its brain. After the stimulation, the pedal is swung back, and the goal box becomes the start box as the animal runs the maze again. The graphs show a comparison of a group running for food as the reward (broken line) with another group running for electric shock as the reward (solid line). Both groups were 24-hours-hungry. The shock-reward group ran as fast as the food-reward group, at the end of the test, and learned almost as fast. The marked day-to-day improvement shown in the first runs of the four days is especially important. The animals of the shock-group averaged over 100 seconds on the first run the first day. They took about 50 seconds on the first run the second day, 30 seconds on the first run the third day, and 12 seconds on the fourth day. This indicates that an animal runs directly to its goal on the first run of the day, having had no pretaste of the electric stimulus to whet its desire.

tion of several rings of cells around the electrode tip induced the rat to stimulate itself with progressively greater frequency. The undulating curves obtained by stimulation in the middle hypothalamus suggest that stimulation of some rings of cells decreases the rate of self-stimulation; from other evidence it is known (2) that "negative" or "punishing" areas infiltrate into the "reward" system in the part of the middle hypothalamus from which these curves were obtained. The "square" curves obtained for the dorsal septal area show that only one ring of cells around the electrode tip had any motivational function; the rest were neutral. Such "square" functions have always resulted when the electrodes were implanted in or near the diagonal band of Broca; the threshold increased as the distance of the electrode from the diagonal band increased. These data on electric current level permit an important inference to be drawn: the asymptotic self-stimulation rate of an area probably depends on the number of concentric rings of "reward" cells surrounding the tip of the electrode.

The square curves indicate several other important points. Since the full rate occurred at 10 microamperes, when the electrodes were in the diagonal band, it appears that cells outside the diagonal band are neutral (the diagonal band is, thus, the only active site in the septal area). The fact that current up to 150 microamperes does not slow the rate of self-stimulation indicates that the reward units of the diagonal band are affected equally by any current from 10 microamperes (threshold) to 150 microamperes (15 times threshold). Since this function was produced repeatedly by the same rat every day for 8 months, it may be assumed that the current of 15 times threshold did no damage to the nearby cells which produce self-stimulation.

Finally, because electrodes may be placed at varying distances from the diagonal band, it is possible to define the shape and size of the suprathreshold electric field produced by various levels of electric current.

Summary. (i) The areas in which the stimulation produces the approach or rewarding effect occupy a larger proportion of the brain than do the areas in which the avoidance or punishing effect is produced. Therefore, the brain cannot be thought of as tending mainly to produce behaviors which *decrease* its own excitation, for a large portion causes behaviors which *increase* excitation. (ii) There is some sort of orderly arrangement of the rewarding effect in the rhinencephalon and related structures, with the result that response rates tend to decline as stimulation is moved forward toward the cortex; this is true both within structures and from structure to structure. (iii) Finally, by gauging the way in which rates of self-stimulation increase as the strength of the brain-shock increases, it is possible to estimate the size of the sphere, surrounding a point of stimulation, in which electric stimulation is rewarding. When the size of this sphere is large, as in the ventral posterior hypothalamus, the rate of self-stimulation at high current levels is very high. When there is only a narrow ring, as in the dorsal septal area, the rate, even at high current levels, is low.

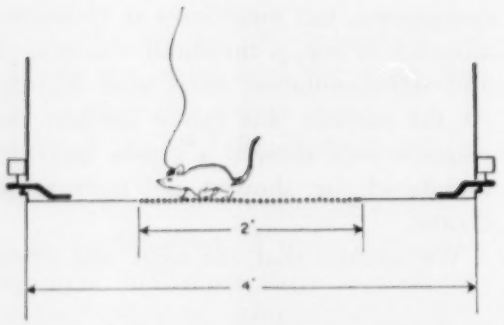


Fig. 7. Obstruction box. An animal receives electric stimulations on one side, then must cross the grid to get more. The animals withstood more foot-shock for the sake of electrical reward than they did when they were 24-hours-hungry and were running for food.

Analytic Studies

Further studies indicate that the electrical brain-shock reward has the effect of a strong primary reward object in several different experimental situations. These studies suggest also that the electric brain shock excites cells which are normally involved in the mediation of the effects of conventional primary reinforcers such as food and sex objects.

Maze running. At first it seemed possible that the animal did not really seek the electric stimulus but pressed the pedal only as a result of some sort of compulsion in a small, confined box. Maze studies (7), however, indicated that animals show day-to-day learning of a complex problem in order to get the electric reward (see Fig. 6). Test animals certainly ran as fast as, if not faster than, others running for a food reward. In the case of a runway instead of a maze (7), animals ran much faster for the electric stimulus than for food.

Obstruction box. The next two studies

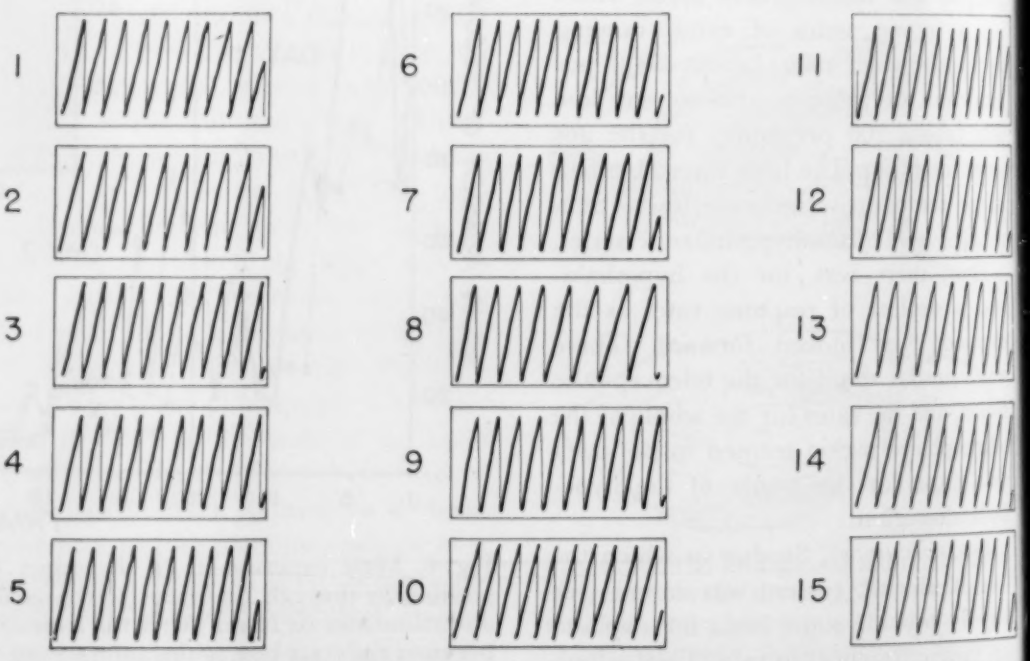


Fig. 8. Response rates in maze studies of one animal for 15 consecutive days. Each square indicates a 1-hour test period on a given day. Each time the record goes from the bottom to the top of a square, the animal has made 500 responses; thus, each peak represents 500 responses or self-stimulations (9). The slope of the rising edge of each "sawtooth" indicates the response rate. There are about ten peaks in each day's record; thus, the animal was responding at the rate of about 5000 responses an hour. The electrode in this case was implanted in the posterior hypothalamus. The same rate is maintained all through the hour, and it is also maintained on all 15 days. Such rates are maintained, in fact, for several months in a row—that is, for as long as we choose to run the animal.

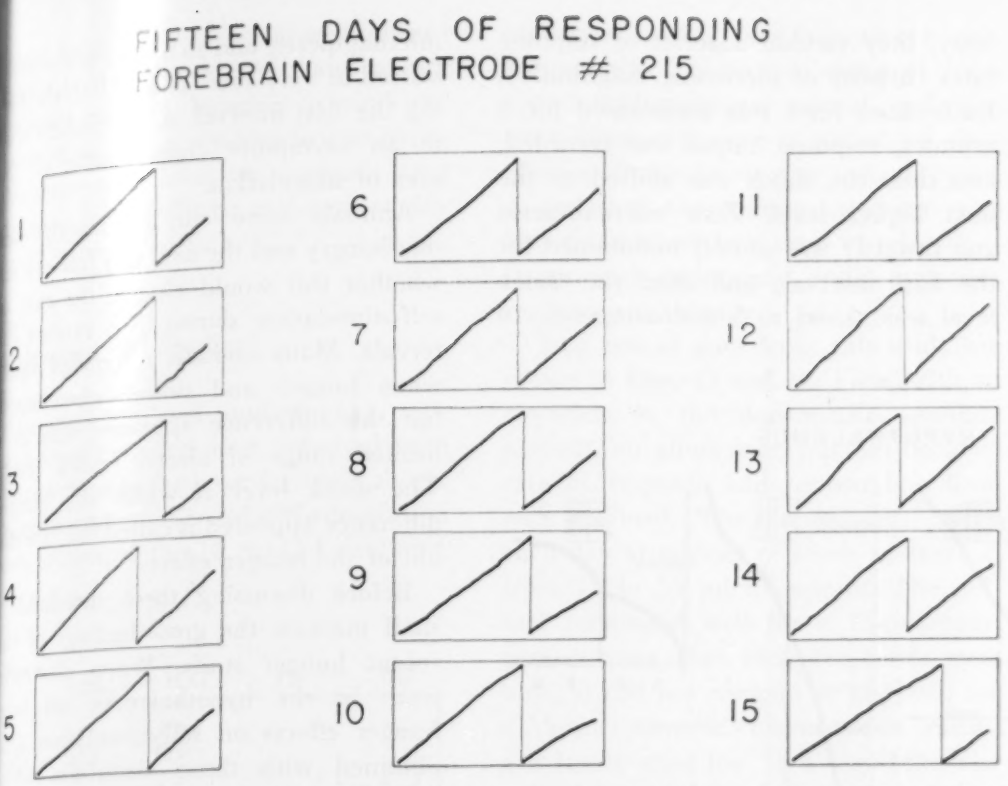


Fig. 9. Diagram similar to Fig. 8, showing response rates in maze studies of an animal with an electrode implanted below the septal region. Here the rate is about 750 self-stimulations an hour.

were concerned with the strength and duration of the drive for self-stimulation. To study the strength of the drive, the obstruction box shown schematically in Fig. 7 was used. In this study (*8*) the rat was permitted to stimulate itself three times at one lever. Then it had to cross a grid, which delivered an increasingly painful foot shock, to stimulate itself three more times at the opposite lever. It went back and forth until the foot shock became so great that it stopped the rat from crossing. Healthy, well-fed rats running for a brain-shock reward endured far more painful shock to the feet than did 24-hour-hungry rats running for food. The drive for self-stimulation appeared to be (in some cases) at least twice as strong as a 24-hour hunger drive.

Satiation? As for the endurance of the drive for self-stimulation, two questions may be asked: (i) How many days did the drive last if rats were allowed to stimulate themselves for an hour per day? (ii) How many minutes or hours did the drive last if rats were allowed to stimulate themselves continuously?

When animals were run for periods of an hour a day, they usually maintained the same rate of self-stimulation throughout the hour and for as many days or months as they were tested. Such stable rates (shown in Figs. 8 and 9) were obtained when high suprathreshold electric current (60 to 100 microamperes) was used.

If animals with electrodes implanted in the hypothalamus were run for 24 hours or 48 hours consecutively, they continued to respond as long as physiological endurance permitted. Rats with electrodes implanted in the telencephalon, on the other hand, seemed to slow down considerably when they were shifted from a 1- to a 24-hour self-stimulation schedule. Figure 10 shows the following pattern: a rate of 2000 self-stimulations per hour maintained for 24 consecutive hours, then sleep, and then further response at a rate of 2000 self-stimulations per hour; this is typical when electrodes are implanted in the hypothalamus. Figure 11 shows rates of self-stimulation for a series of animals on such a regime. All curves obtained from animals with electrodes in the telencephalon have early, sharp inflection points. An animal with an electrode in the telencephalic septal area, which responded 1000 times per hour if it was permitted to stimulate itself for only one hour per day, responded only 1000 times in 24 hours if it was permitted to stimulate itself for 24 hours per day. Thus, animals with electrodes in the telencephalon appeared to show some genuine satiation. No similar satiation appeared in animals with electrodes in the hypothalamus.

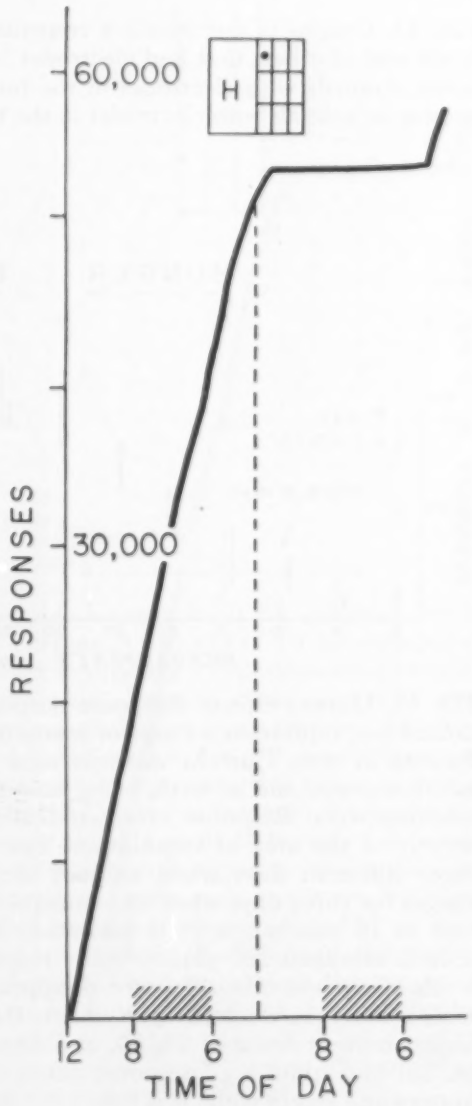


Fig. 10. Graph of continuous self-stimulation for a 48-hour period. Cumulative response totals are plotted along the ordinate, hours along the abscissa. The experiment started at noon; cross-hatching indicates darkness from 8 P.M. to 6 A.M. The animal (with an electrode implanted in the anterior medial hypothalamus) stimulated itself at a rate of more than 2000 responses an hour for 26 hours, then slept, and then resumed self-stimulation at the same rate.

Effects of drives. Further studies showed that the animal's taste for the electric reward is often sensitive to basic drives in the way that its taste for conventional rewards is. The extensive reward system appears to break down into subsystems subservient to the different basic drives; there appears to be a food-reward system, a sex-reward system, and so on.

If electric stimulation at some points fires cells that mediate food reward, the animal's appetite for self-stimulation at this point may go up and down with hunger as its appetite for food does. A large series of animals has been tested in order to compare their rates of self-stimulation when hungry with their rates when full. When tests were made at a constant current of 65 microamperes with a set of electrodes placed in the midline of the brain, in the ventromedial hypothalamus, and in the septal area,

hunger seemed to have an important positive effect, increasing self-stimulation rates (*9, 10*). When, however, animals were tested at *a series of current levels,* a somewhat different picture of the hunger system appeared.

In the latter experiments (as shown in Fig. 12) animals were tested every day at a series of shock levels; accordingly, they yielded a series of response rates (usually of increasing magnitude). Each shock level was maintained for 8 minutes, response output was recorded, and then the shock was shifted to the next higher level. Zero microamperes (no reward) was usually maintained for the first interval, and then the shock level was raised to 5 microamperes, 10 microamperes, and so on. Response rates started at very low (chance) levels during the first interval and gradually rose to an asymptote characteristic of the area of stimulation.

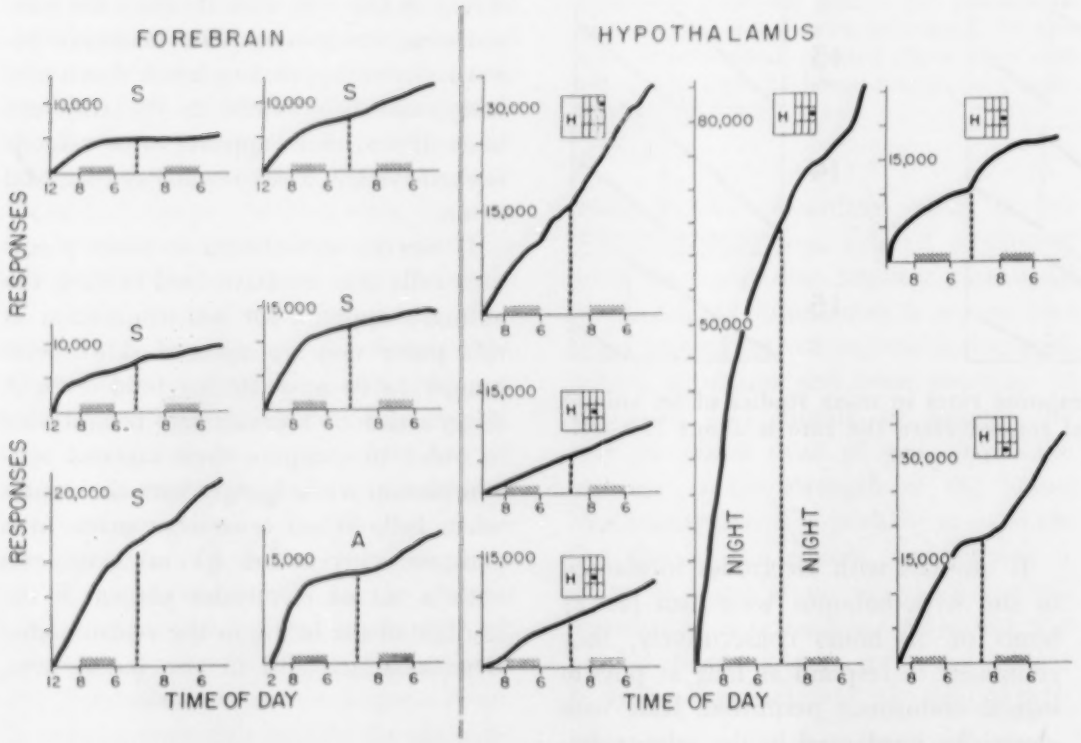


Fig. 11. Graphs of comparative responses of animals with electrodes implanted in forebrain and of others that had electrodes in hypothalamus, in a continuous 48-hour experiment. Animals with electrodes in the forebrain show a point of satiation which does not appear in animals with electrodes in the hypothalamus.

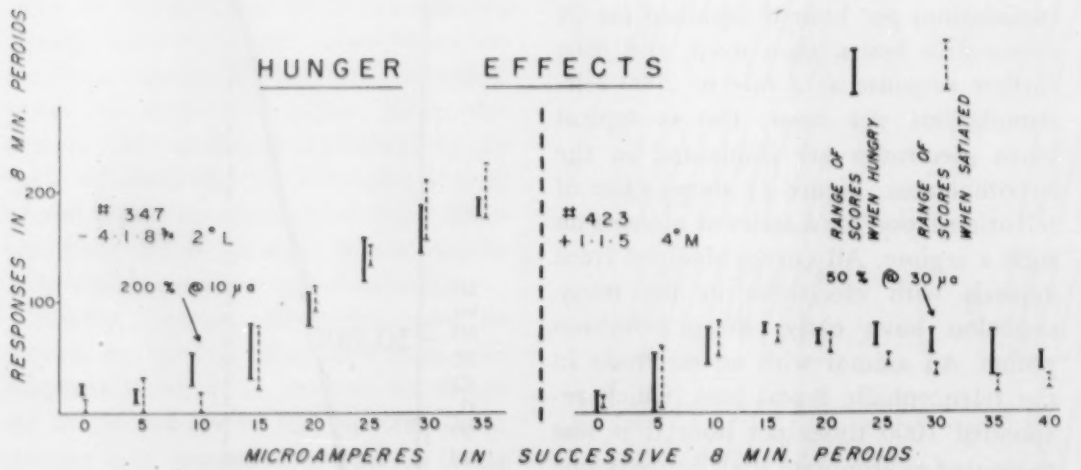

HUNGER EFFECTS
RESPONSES IN 8 MIN. PERIODS
347
- 4 · 1 · 8 h 2° L
200 % @ 10 μa
423
+ 1 · 1 · 5 4° M
RANGE OF SCORES WHEN HUNGRY
RANGE OF SCORES WHEN SATIATED
50 % @ 30 μa
MICROAMPERES IN SUCCESSIVE 8 MIN. PERIODS

Fig. 12. Hunger effects. Response output is plotted against electric current; each bar or dotted line represents a range of scores obtained on several days. The testing started with current at zero. Current was increased after 8 minutes to 5 microamperes, then to 10 microamperes, and so forth, being maintained for 8 minutes at each level up to 35 or 40 microamperes. Response rates gradually increased, approaching an asymptote characteristic of the area of stimulation. The heavy black lines represent response ranges for three different days when animals were 24-hours-hungry; the broken lines represent ranges for three days when the animals were full. At the left, a sharp hunger differentiation at 10 microamperes is indicated. There is no overlap of scores at this point. The animal averaged 200 percent more responses when it was hungry. However, at all other levels of current this difference disappears. At the right are scores for a different animal with a different electrode placement. Here there is a marked separation of scores at the higher current levels of 25, 30, and 35 microamperes. But at the lower levels, where the animal had quite high response rates, there is no difference between scores while it is hungry and scores while it is full.

Before discussing these thresholds I shall mention the gross findings of this recent hunger study. When electrodes were in the hypothalamus, all large hunger effects on self-stimulation were obtained with those electrodes which were clustered in the posterior sector. No hunger effects were found when electrodes were in the portion of the anterior hypothalamus that was explored. With electrodes in the telencephalon, however, strong hunger effects appeared again in a rather unclear pattern. With electrodes in the posterior hypothalamus, the interesting and orderly picture shown in Fig. 13 was obtained.

Thresholds for the hunger effect declined as the location of the electrodes approached a point about 1.25 millimeters lateral to the midline at a point just in front of the mammillary body. If we assume that a hunger-reward center is located at this point, we find that it can be reached by 10 microamperes of current from electrodes at points about 0.25 millimeter away and by 20 microamperes from electrodes at points about 0.5 millimeter away. From these data we may surmise (see Fig. 14) that a 50-microampere stimulus has a suprathreshold field with a diameter of about 1 millimeter.

Electric stimulation in the whole posterior hypothalamus has rewarding effects, for stimulation through electrodes anywhere in this area produces very high rates of response even at the lowest current levels. Only stimulation of areas shown schematically at the lower left of Fig. 14, however, seems related to hunger; the other areas must be controlled by other drives.

A hunger differential appears, we may surmise, whenever an electric field is increased to the point where there is a hunger-sensitive area on the boundary between the supra- and subthreshold parts. If this is true, our data suggest a

sharp localization of a hunger reward center in the hypothalamus and a very compact relation between it and the other drive-reward centers in the hypothalamus—a relation so compact that different effects will be achieved at different current levels.

Androgen-Level Studies

In androgen-level studies (*11*), animals were castrated after they had been trained to press the lever for brain shock. After castration, rates of self-stimulation were measured for 14 days of declining androgen level. Then testosterone propionate was injected, in doses of from 1 to 5 milligrams per animal, and rates were measured over a period of days while androgen levels rose and fell again. A series of testosterone injections was also given to see how rates of self-stimulation were maintained under androgen replacement therapy.

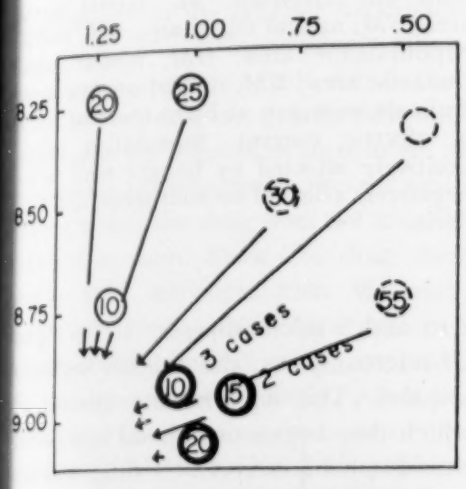


Fig. 13. Hunger map. This is a schematic map of the region of the posterior hypothalamus. (Electrodes 8 to 9 mm long are implanted 4 mm behind the primary skull marking bregma.) The ordinate gives distance (in millimeters) from the top of the skull. The abscissa gives distance (in millimeters) from the midline. Thus, the right side of the drawing represents the medial portion of the hypothalamus. The very dark circles indicate electrode implantations accompanied by very large hunger effects; plain circles indicate those accompanied by moderate effects; broken circles indicate those accompanied by very small effects. The broken circle without a numeral indicates no hunger effect at all. The numerals inside the other circles indicate the level of current (in microamperes) at which the hunger effect could be detected. In the case of the electrodes represented by the cluster of circles at the lower left-hand corner of the map, levels of current of about 10 microamperes produced the hunger effect. With electrodes represented by circles above this point, current levels of 20 and 25 microamperes gave the hunger effect. With electrodes nearer the midline, currents of 30, then of 55, microamperes were required to get hunger differentiation, and even then it was small. With the electrodes represented by circles in the top medial part of the square, no hunger effect is detected at any of the levels of stimulation used. It is almost, but not quite, true that the distance from a point 9 mm deep and 1.25 mm lateral determines the amount of current needed to get the hunger effect.

Two sets of data from this study are shown in Figs. 15 and 16. First, with an electrode in the dorsomedial caudate nucleus, an all-or-none relation between rate of response and testosterone level was obtained. The animal was tested each day at a series of levels of current, from 15 to 55 microamperes. The animal responded well for a 15-microampere current when androgen levels were high; it did not respond at all, even for a 55-microampere current, when androgen levels were low (see Fig. 15). The animal was taken through several androgen cycles. At high levels it always responded; at low levels it did not. At the termination of its career the rat was responding at a very high level, and postmortem examination showed that its seminal vesicles were not only as large as those of noncastrated rats but, indeed, were larger than normal. Thus, it is possible to get all-or-nothing drive effects from self-stimulation with electrodes placed in some parts of the caudate nucleus.

The second point is that there is an inverse relation between androgen effects and hunger effects on the rate of self-stimulation (see Fig. 16). Hunger effects and androgen effects on rate of self-stimulation were measured in 16 animals, with electrodes in different parts of the hypothalamus and telencephalon, on 1-hour self-stimulation runs with a stimulus of 1 volt (about 60 to 80 microamperes). Animals which showed a strong increase in rate of self-stimulation in response to androgen showed a decline in rate of self-stimulation in response to hunger, and vice versa. In other words, if hunger raised the response rate, androgen lowered it; if androgen raised the response rate, hunger lowered it. If we presume that the placement of the electrode determines the degree of sensitivity to hunger or to androgens, this study gives a firm basis for expecting to find anatomical differentiation between the hunger-reward system and the androgen-reward system.

Other experiments showed the effect of forced electric stimulation on food consumption (consummatory behavior). In these experiments (*12*), electrodes were implanted and were used first to test the effect of stimulation on food consumption. The animals were maintained on an *ad libitum* diet. Eating, under stimulation, in stimulation boxes, was measured for 1 hour per day with current of about 80 microamperes applied for 0.5 second every 10 seconds. Other groups were stimulated with current of 25 microamperes applied for 0.5 second every second. Measures of food intake under stimulation were matched against food intake during control weeks during which there was no stimulation. As has been reported by others (*13*), stimulation in the ventral posterior hypothalamus at points about 1.5 millimeters lateral to the midline caused an increase in eating; stimulation medial to these points sometimes, but not always, caused a decrease in eating. After these tests were completed, the same animals were subjected to self-stimulation tests with the same levels of current. The lateral electrode placements, in areas where stimulation seemed to increase hunger drive, were the ones that usually produced extremely high rates of self-stimulation. The medial placements, in areas where stimulation seemed to reduce the

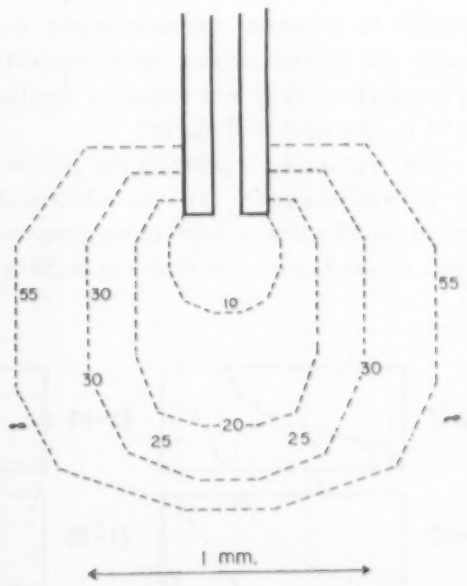


Fig. 14. Electric fields for different levels of current. A current of 10 microamperes seems to produce a suprathreshold electric field which extends more than 0.25 mm downward but a much shorter distance out to the sides and a still shorter distance upward; 20 microamperes seems to reach about 0.75 mm downward; 55 microamperes, about 1 mm. If reference is made to this schematic drawing of the field in connection with each point on the diagram of hunger effects (Fig. 13), it may be seen that the boundary of the suprathreshold field cuts through the supposed hunger point at the shock level where the hunger difference appears. This drawing is intended to suggest orders of magnitude but not exact relationships.

hunger drive, ordinarily produced much slower rates of self-stimulation.

To avoid the notion that there is a food-reward "center" in the posterior hypothalamus, it should be mentioned that a similar relationship between hunger and electric stimulation seems to exist in several more anterior parts of the brain. Figure 17 shows the effect from a rewarding electrode placement in the telencephalon. Electric stimulation at this point increased eating behavior by almost 50 percent, and the animal stimulated itself at a rate of over 1000 responses per hour with no change in level of current.

There is a superficial anachronism in these data correlating drive increase (measured by eating behavior) and reward (measured by self-stimulation); reward has classically been thought to be correlated with drive reduction. There is, of course, the possibility that some conflicting drive is reduced by the stimulation, thereby permitting the animal to eat. There may also be neighboring drive and reward areas, both activated by the same electric field. However, the correlation of rewarding properties with a stimulus which produces consummatory behavior need not be surprising. If we think, for example, of a stimulus to a sexual consummatory response, we might expect some rewarding properties. Why not expect a similar result in the case of hunger?

Thus, our analysis permits the following generalizations: (i) the electrical reward is effective where more conventional rewards are effective—in a Skinner box, runway, complicated maze, and obstruction box; (ii) the reward has the same effect from day to day over long periods of time; (iii) with stimulation through electrodes in some brain areas, hunger augments the rate of self-stimulation, and with stimulation through electrodes in other brain areas, androgens augment the rate; (iv) the rewarding stimulus often appears to produce a temporary increment in some consummatory behavior.

Drug Studies

The last part of this article deals with more practical considerations. It seems that certain behavior disorders might be benefited if "reward" or "pleasure" systems of the brain could be selectively controlled by use of pharmacological agents. It might be important to control one of the drive-reward systems without affecting the other systems, or to control the forward or cortical reward systems without affecting the posterior, hypothalamic systems.

For these reasons we have hoped to find differential sensitivity of different reward placements to different drugs with known emotional or psychological effects. In recent drug studies (*14*), series of levels of current were used, as in the drive studies. Animals were allowed to stimulate themselves for eight minutes at each level of current, starting at zero and working up to 40 or 50 microamperes. As was indicated previously, the animals did not respond at zero and 5 microamperes. At 10, 15, or 20 microamperes, the animals began to respond. The eight-minute interval in which they began to respond was called the threshold interval. A drug was injected, to become effective at the beginning of the threshold interval (which had been determined by several weeks of previous control testing).

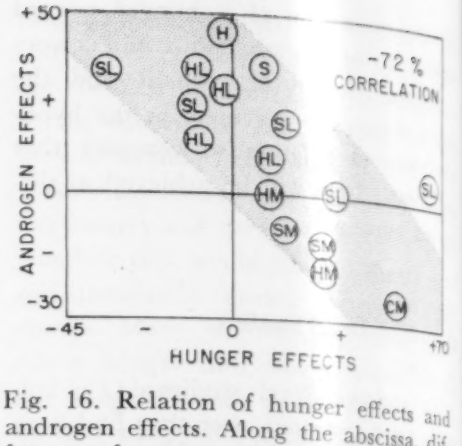


Fig. 16. Relation of hunger effects and androgen effects. Along the abscissa, differences from control rates caused by 24 hours of hunger are plotted as percentages of control rates. Along the ordinate are plotted similar differences caused by administration of 2 milligrams of testosterone to castrated animals. Each point represents one electrode. *SL*, lateral septal area; *SM*, medial septal area; *HL*, lateral hypothalamic area; *HM*, medial hypothalamic area; *CM*, medial caudate area. Animals were run at high, constant levels of electric current. Stimulation points positively affected by hunger tend to be negatively affected by androgens, and vice versa.

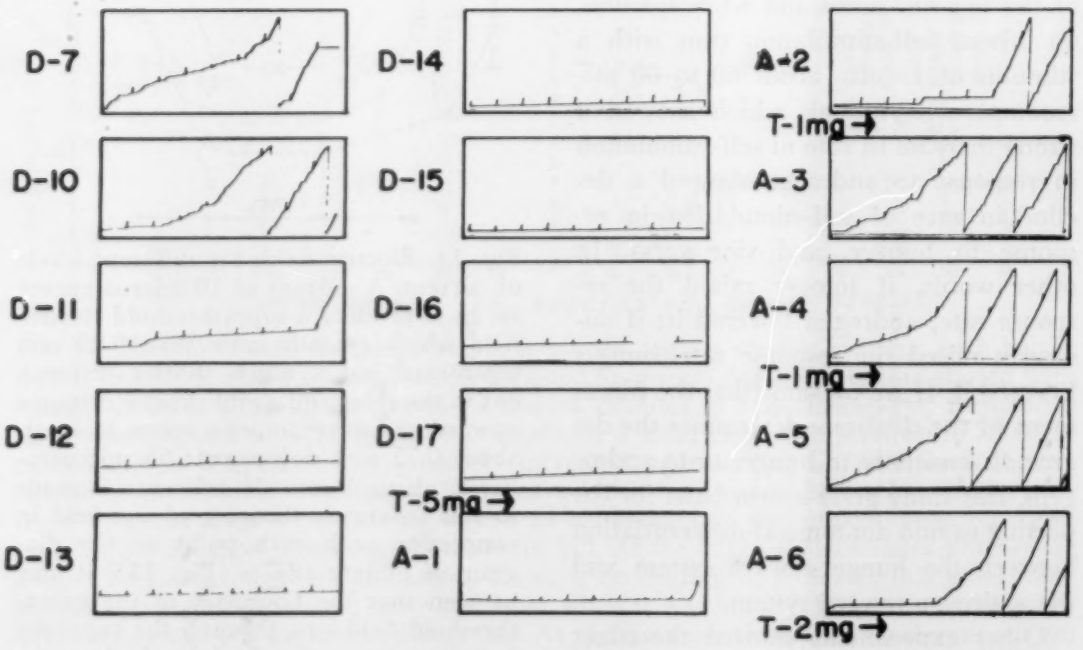


Fig. 15. Effect of androgen on threshold of response to stimulation, showing threshold changes from day 7 after castration to day 17 after castration and reversal of these changes by injection of 5 mg of testosterone propionate in oil. Animals are tested each day at levels of current that increase from 15 to 55 microamperes by steps of 5 microamperes.

Tranquilizers. In the bar graphs of Fig. 18 the rate of self-stimulation is shown for successive levels of current after threshold has been reached (these graphs start, that is, with the threshold interval). Restangular outlines show the average rate of response for the day before, and the day after, the drug test. The dark bars indicate the rate of self-stimulation when the animal was under the influence of the drug. The dotted lines show the degree of the effect of the drug. In Fig. 18 the data are for chlorpromazine injected intraperitoneally at 2 milligrams per kilogram. In the case illustrated at the left of Fig. 18, in which the electrode was in the middle hypothalamus, none of the self-stimulating response was eliminated at threshold, only 25 percent of the response was eliminated at the next level, and 21 percent was eliminated at the third level, after which all inhibitory effect of chlorpromazine was over, in this case. In the case illustrated at the right, in which the electrode was placed in the ventral posterior hypothalamus, the effect was much more pronounced; self-stimulation

is totally eliminated in all six of the intervals shown.

A map of the effects of chlorpromazine obtained with 31 cases has been made. It shows that the effects of chlorpromazine are strongly inhibitory on self-stimulation when electrodes are placed in the ventral posterior hypothalamus. With electrodes in the middle hypothalamus, there is a somewhat less marked effect, and with electrodes in the anterior hypothalamus, there is very little effect. The effects are small with electrodes in the anterior preoptic region but seem to become quite strong again with electrodes in parts of the septal region.

With electrodes in the posterior hypothalamus and in the anterior hypothalamus, the same drug has strikingly different effects on the rate of self-stimulation. Since the drug does not greatly slow self-stimulation via electrodes implanted in the anterior hypothalamus, there is some assurance that the drug does not impede behavior as such. Since the drug does greatly slow self-stimulation via electrodes implanted in the ventral posterior hypothalamus, there is some assurance that the drug acts selectively, either on this part of the brain or on some of the areas to which it projects, to produce its rewarding effect. Furthermore, it is reasonable to assume that the areas sensitive to the drug are not essential to all rewarding effects, because anterior hypothalamic stimulation has its rewarding effect in spite of the drug.

Psychotomimetics. Another example of a differential drug effect is the interaction of serotonin and lysergic acid diethylamide. Serotonin is supposedly a transmitter substance in the brain, and lysergic acid diethylamide is a psychotomimetic (producing effects somewhat similar to psychotic hallucinations). Studies by other workers (*15*) have suggested that in some cases serotonin might be antagonistic to the effects of lysergic acid diethylamide. When lysergic acid diethylamide was injected intraperitoneally just prior to the threshold interval, there was usually an inhibitory effect on self-stimulation. In most cases the drug was effective in both the first and second intervals after injection. The effect of the drug appeared most dependably in the second eight-minute interval after injection; therefore, we studied the inhibitory effect on self-stimulation in this second interval in further analysis. We found two types of interaction between lysergic acid diethylamide and serotonin. In the first, lysergic acid diethylamide alone had a strong inhibitory effect on self-stimulation; when serotonin was administered half an hour before the lysergic acid diethylamide injection, however, there was no effect of the latter at all. Finally, bromo-lysergic acid diethylamide, which is like lysergic acid diethylamide but is supposed not to cross easily from the blood into the brain, had no inhibitory effect on self-

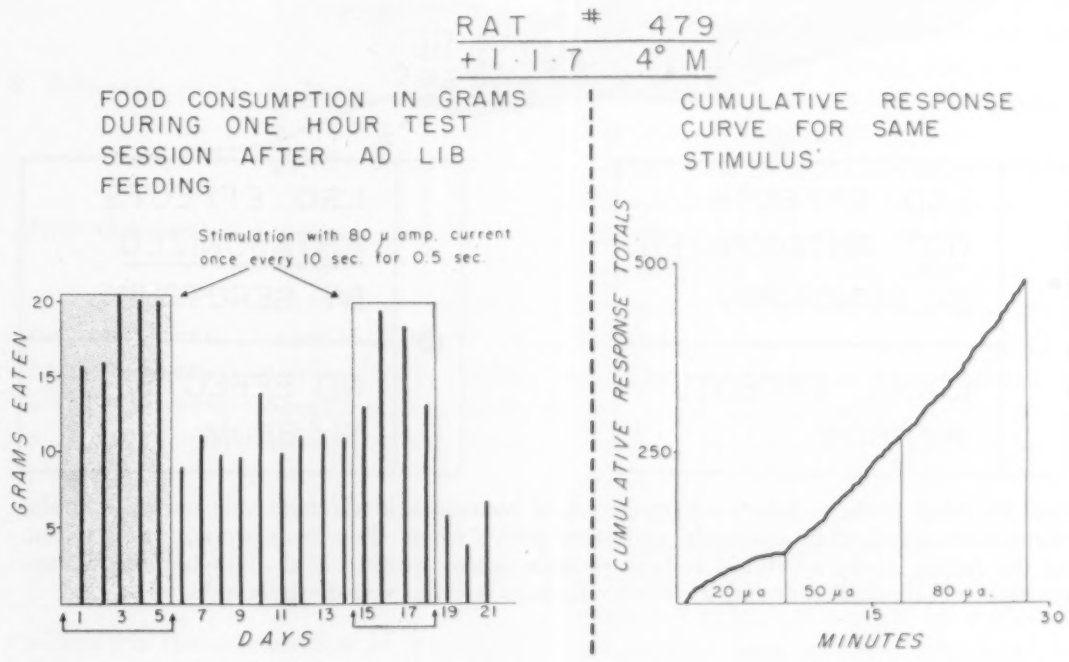

RAT # 479
+1·1·7 4° M
FOOD CONSUMPTION IN GRAMS DURING ONE HOUR TEST SESSION AFTER AD LIB FEEDING
Stimulation with 80 μ amp. current once every 10 sec. for 0.5 sec.
GRAMS EATEN
DAYS
CUMULATIVE RESPONSE CURVE FOR SAME STIMULUS
CUMULATIVE RESPONSE TOTALS
20 μa
50 μa
80 μa.
MINUTES

Fig. 17. Eating behavior produced by "rewarding" stimulus.

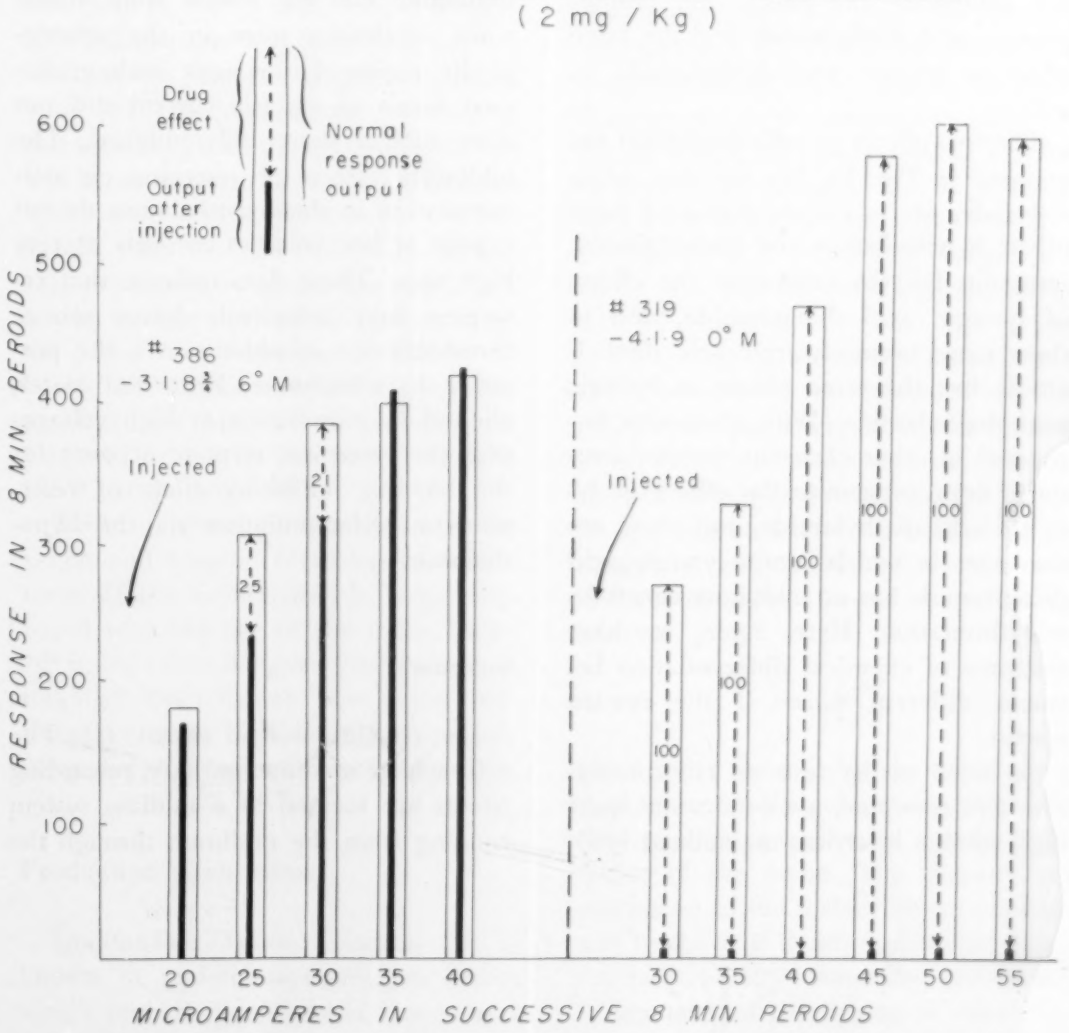


Fig. 18. Differential effects of chlorpromazine. Rectangles show normal response output. Black bars show output under influence of chlorpromazine. The animal for which data are given at left was almost unaffected by the drug. The animal for which data are given at right was almost totally inhibited; the difference is attributed to the more posterior position of the electrode in the latter case.

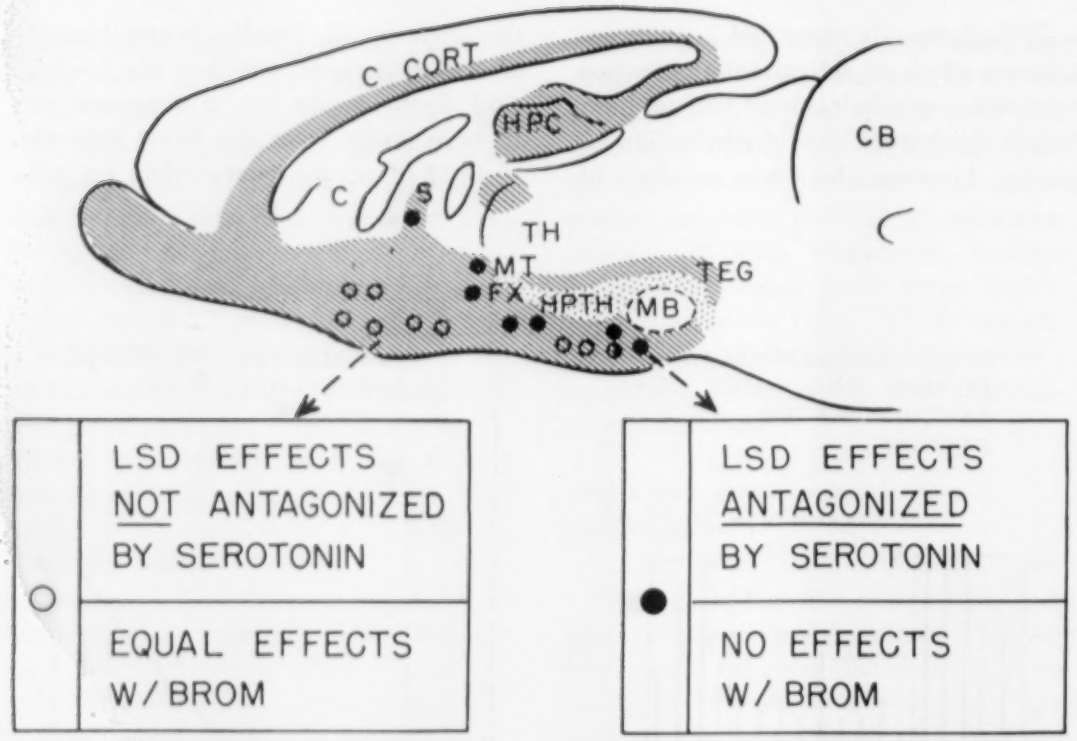


Fig. 19. Map showing points where effects of lysergic acid diethylamide on self-stimulation are antagonized by serotonin and other points where the effects are not antagonized. At the points where serotonin fails to protect againt lysergic acid diethylamide, bromo-lysergic acid diethylamide has the same effects as lysergic acid diethylamide itself.

stimulation. In the second case, lysergic acid diethylamide had a strong effect again. This time, however, serotonin did not antagonize the effect, and bromo-lysergic acid diethylamide had the same effect as lysergic acid diethylamide itself.

The two effects on self-stimulation are mapped in Fig. 19. We see that when electrodes are in certain delimited parts of the hypothalamus and telencephalon, serotonin fails to antagonize the effects of lysergic acid diethylamide, and in these cases bromo-lysergic acid diethylamide has the same effects as lysergic acid diethylamide. With electrodes implanted in other clear-cut regions, serotonin does antagonize the effects of lysergic acid diethylamide, and these are the cases in which bromo-lysergic acid diethylamide has no inhibitory effects on self-stimulation. Here, again, we have evidence of chemical differentiation between different parts of the reward system.

In some earlier tests on chlorpromazine and reserpine, a constant and quite high voltage level was maintained (*16*). Striking inhibition of response tendencies by reserpine was found when electrodes were implanted in the posterior hypothalamus, but no effects were found when electrodes were in the telencephalic region. Later work with graduated levels of electric current did not show such a sharp differentiation. The inhibitory effects of reserpine on self-stimulation in the hypothalamus do not appear at low voltages but only at very high ones. These data indicate that reserpine may selectively lower seizure thresholds for stimulation via the posterior hypothalamus. Petit mal states, elicited by stimulation at high voltages plus the reserpine, seem to account for the seeming inhibitory effect of reserpine on self-stimulation via the hypothalamus.

Summary

My conclusions are these: (i) The cells which mediate primary rewarding effects are located in a midline system running from the midbrain through the hypothalamus and midline thalamus and into the subcortical and cortical groups of the rhinencephalon. (ii) The cell groups which mediate primary rewarding effects are different from those which mediate primary punishing effects. (iii) Despite this relative independence, there are, undoubtedly, relationships of mutual inhibition existing between these two systems. Rewards do, among other things, tend to reduce sensitivity to pain, and punishments do tend to reduce rewarding effects. (iv) These primary reward systems of the brain are subdivided into specific drive-reward subsystems mediating the specific drives such as hunger and sex. (v) Because there are also subsystems of this set of rewarding structures sensitive to different chemical effects, it is reasonable to hope that eventually it will be possible to control the reward systems pharmacologically in cases where behavior disorders seem to result from deficits or surfeits of positive motivation.

References and Notes

1. These studies were aided by a grant from the Foundations Fund for Research in Psychiatry ("Brain Mechanisms and Motivation") to H. W. Magoun and J. Olds, by contract NR 144-102 [Nonr-233 (32)] between the Office of Naval Research, U.S. Department of the Navy, and the University of California, and by a grant from the Carnegie Corporation of New York ("Brain Organization and Behavior") to R. B. Livingston and D. B. Lindsley.
2. J. Olds, *J. Comp. and Physiol. Psychol.* 49, 281 (1956).
3. J. Olds and P. Milner, *ibid.* 47, 419 (1954).
4. W. R. Hess, *Das Zwischenhirn* (Schwabe, Basel, Switzerland, 1949).
5. B. F. Skinner, *The Behavior of Organisms* (Appleton-Century, New York, 1938).
6. J. M. R. Delgado, W. W. Roberts, N. E. Miller, *Am. J. Physiol.* 179, 587 (1954).
7. J. Olds, *J. Comp. and Physiol. Psychol.* 49, 507 (1956).
8. This study was made in collaboration with J. C. Sinclair.
9. J. Olds, "Differential Effects of Drives and Drugs on Self-Stimulation at Different Brain Sites," in D. E. Sheer, Ed., "Electrical Stimulation of the Brain," proceedings of the University of Houston and the Hogg Foundation Symposium on Brain Stimulation, 26–28 Apr. 1956, in press.
10. ———, "Neurophysiology of Drive," *Psychiat. Research Repts.* 6, 15 (1956).
11. These studies were made in collaboration with B. V. Critchlow.
12. These experiments were made in collaboration with R. Wendt.
13. J. M. R. Delgado and B. K. Anand, *Am. J. Physiol.* 172, 162 (1953).
14. These studies were made in collaboration with K. F. Killam and S. Eiduson.
15. D. W. Wooley, *Proc. Natl. Acad. Sci. (U.S.)* 41, 338 (1955).
16. J. Olds, K. F. Killam, P. Bach-y-Rita, *Science* 124, 265 (1956).

Possible Sources of a Lunar Atmosphere

W. F. Edwards and L. B. Borst

Although the moon is usually considered to have no atmosphere, recent observations by the methods of radio astronomy are best explained by the assumption of a pressure of 10^{-13} atmosphere. Elsmore (*1*) reports the occultation by the moon of two radio sources. In each case the distribution of brightness is dependent on wavelength and has a shape which implies refraction at the day side of the moon's disk. The estimated electron density is 1000 electrons per cubic centimeter, which Elsmore attributes to an atmosphere "about 2×10^{-13} of that of the terrestrial atmosphere at N. T. P. and in no circumstances greater than 6×10^{-13}" (*2*).

As in the case of the earth, it is thought that the moon lost volatile materials during the period of formation (*3*), so that the only mechanisms of atmosphere production which can be relied upon are those which occur subsequent to the process of element formation or planet formation.

The low gravitational field of 167 centimeters per second per second gives an escape velocity of only 2.37 kilometers per second, so that gases of low molecular weight will not be retained. Kuiper (*4*) suggests that molecules of weight less than 60 will be lost during the heat of the lunar day (135°C).

This article evaluates several sources of the heavy rare gases krypton and xenon, which are thought to be too heavy to escape. These sources are (i) spontaneous fission of uranium-238, (ii) fission of uranium-235 by thermal neutrons from cosmic rays, (iii) thermal fission of uranium-235 from the reaction

$$O^{18}(\alpha,n)Ne^{21}$$

(iv) xenon production from iodine-129 produced during the formation of the elements, and (v) primeval gases trapped in rock.

Mr. Edwards is on the staff of California Institute of Technology, Pasadena; Dr. Borst is chairman of the department of physics at New York University, New York, N.Y.

Rate of Escape

To examine the rate of escape of krypton and xenon, formulae derived by Spitzer (*5*) are used. The time t_1 during which the particle density would fall by a factor of e for an isothermal atmosphere is

$$t_1 = \frac{2\sqrt{6\pi}C^3}{9gV_\infty^2} e^{3V_\infty^2/2C^2}$$

where g is the acceleration of gravity, C is the root-mean-square velocity of the molecule, and V_∞ is the escape velocity.

The assumption of an isothermal atmosphere is well founded, since the mean free path at 400°K and at a pressure of 10^{-13} atmosphere will be 600 kilometers, whereas the height to which a molecule with the root-mean-square velocity C can ascend against the gravitational field will be, at most, 10 kilometers. Collisions between molecules will therefore be rare events, whereas collisions at the surface will predominate. Molecular paths will not be straight but will be, rather, elliptic. Since most molecular collisions will be with the surface at a well-defined temperature, the Maxwellian gas temperature will be that of the moon's surface, 135°C at the lunar noon.

Table 1 gives the escape time for xenon and krypton at various temperatures. If the escape time is large compared with the age of the moon (4.5×10^9 years), then the gases evolved will be retained. Even though "hot spots" with temperatures as high as 700°K may develop, krypton and xenon will not be lost.

Production Mechanisms

Spontaneous fission. Uranium-238 is known to undergo spontaneous fission with a probability of 5.4×10^{-7} per alpha decay. While the decay constant is small ($\lambda = 2.7 \times 10^{-24}$ per second) on a geological scale, it cannot be neglected.

The accumulation of stable fission products or a single fission product may be represented by the expression

$$N = \frac{\lambda_i N_p}{\lambda}(e^{\lambda t} - 1)$$

where N_p is the number of parent atoms remaining at the present time, λ_i is the decay constant giving the desired product, λ is the decay constant for the disappearance of the parent, and t is the time interval during which the product has been accumulating.

The yields of xenon and krypton from the spontaneous fission of uranium-238 have been measured by Thode (*6*) and by Wetherill (*7*). The total yield of xenon is 15 percent; of krypton, 0.92 percent.

Estimates of the uranium content of the moon are restricted at the lower limit by the uranium content of stony meteorites. As an upper limit, the concentration must not be sufficiently high to cause melting of the interior. Urey (*8*) concludes that the best value is 0.012 parts per million by weight for the moon as a whole, with possible enrichment by a factor of two at the surface.

The numbers of atoms of krypton and xenon generated in surface layers of various depths are given in Table 2. The assumptions are (i) uniform uranium concentration (0.012 micrograms of uranium per gram); (ii) density of layer, 3 grams per cubic centimeter; (iii) age, 4×10^9 years; (iv) no escape of krypton or xenon; (v) complete loss of primeval rare gases during planet formation. In a surface layer 1 centimeter deep, 2.5×10^{24} xenon, and 1.5×10^{23} krypton, atoms will be generated.

If released as a free atmospheric gas, the total number of molecules will depend upon the thickness of the surface layer which has been outgassed. The atmospheric pressure at the surface, based on the assumption of an isothermal atmosphere, will be related to the total number of molecules by the following relation:

$$P = \frac{mgN}{4\pi R_0^2}$$

where m is the mass of the molecule, g is the acceleration of gravity, N is the total number of molecules, and R_0 is the radius of the moon. The pressure per centimeter of the surface layer outgassed will be 9.1×10^{-22} atmosphere for krypton and 1.4×10^{-20} atmosphere for xenon.

Estimates of the degree to which the moon will be outgassed depend intimately upon the detailed model chosen. The stability of the moon's surface, made evident by the existence of numerous

Table 1: Escape times for heavy rare gases from the moon (in years).

Gas	Temperature (°K)			
	400	700	1000	1500
Xenon	10^{41}	5×10^{29}	6×10^{12}	4×10^{6}
Krypton	10^{24}	2×10^{11}	10^{6}	2×10^{3}

craters, precludes continuous outgassing of a surface layer by processes similar to geological gradation on the earth. Complete outgassing probably occurred at some stage, but this stage would be difficult to distinguish from the period of planet formation. The total stockpile of noble gases in the whole moon produced by spontaneous fission in the past 4000 million years corresponds to a pressure of 1.1×10^{-12} atmosphere (1.5×10^{32} atoms). Ten percent of the total gas accumulated in 4000 million years would have had to diffuse to the surface to produce an atmosphere of pressure 10^{-13} atmosphere.

In the event that there is some segregation of materials, uranium would undoubtedly be concentrated at the surface. Urey suggests twofold or threefold concentration at the surface. With this concentration of uranium, the thickness of crust would be perhaps 10 kilometers at a very minimum.

If one identifies certain markings on the moon's surface as cracks produced by heating and expansion of the interior, these may indicate channels of communication between the atmosphere and the outer layer. Diffusion through massive rock would then not be necessary.

Radio astronomical observations give evidence that the surface of the moon is a finely divided dust, and Urey proposes pumice as the most probable surface rock. It is therefore probable that diffusion does indeed account for the transfer of gases from a limited surface layer.

It is doubtful, however, whether all parts of a layer 10 kilometers deep are in continuous communication with the free atmosphere.

The collision of meteors has undoubtedly been responsible for the outgassing of the top few kilometers of the moon's surface. The question at issue is: When did these cataclysmic events occur? If they occurred shortly after formation of the planet, insufficient spontaneous fission would have occurred. By assuming a surface concentration sufficiently above the interior, the required amount of gas may be released. If, on the other hand (but this is not probable), meteoric activity has been uniform and continuous up to the present time, there would be no difficulty in releasing fission-product rare gases to the atmosphere in the required quantity.

Cosmic ray bombardment. Soberman (*9*) reports the total neutron flux on the earth from cosmic rays as 5.8×10^{18} neutrons per second. At the present epoch the moon, therefore, receives a total flux of 6×10^{17} neutrons per second. The effective total absorption length is 150 to 200 grams per square centimeter, so that the neutrons will be generated and absorbed within the first meter of the moon's surface. It is therefore acceptable to assume that these fission gases will continuously diffuse to the surface to form an atmosphere as a consequence of thermal cycling during the lunar day.

This proposed mechanism requires the assumption of constant cosmic ray intensity. It is only possible to say, in this regard, that studies involving carbon-14 seem to confirm this constant intensity over a few thousand years.

While cosmic ray neutrons have initial energies of many millions of electron volts, in a medium composed largely of silicon and oxygen most of them will be moderated to thermal energies of a small fraction of an electron volt before absorption.

The fraction of neutrons captured by uranium-235 to produce fission will be determined by the composition of the rock and the thermal neutron absorption cross sections. This fraction, if one assumes a composition similar to that of the earth's crust except for uranium, is 6×10^{-8}.

The generation rate at present for xenon is therefore 5×10^{9} atoms per second for the whole moon. In the past, however, the production rate was greater because of higher concentration of uranium-235. The total production of xenon is given by the expression

$$N = \frac{N_p \sigma}{\sum_i N_i \sigma_i} \frac{n v y}{\lambda} (e^{\lambda t} - 1)$$

where N_p is the number of uranium-235 atoms present today, n is the neutron flux, λ is the decay constant for uranium-235, and y is the fission yield of noble gases (assumed for thermal neutrons on uranium-235 to be 25 percent). The total number of atoms of rare gas is 4.9×10^{25} atoms for a period of a billion years and 1.5×10^{27} atoms for a period of 4×10^{9} years, a factor of 10,000 too small to account for the observed atmospheric pressure of 10^{-13} atmosphere.

Alpha-neutron source. An additional source of neutrons in geological deposits has been reported by Inghram (*10*) to be produced by nuclear interactions of alpha particles from radioactive substances. He finds unusual abundances of neon-21, neon-22, and argon-38 in uranium and thorium minerals and attributes them to the following reactions:

$$O^{18}(\alpha,n)Ne^{21}$$
$$F^{19}(\alpha,n)Na^{22}$$
$$Na^{22} + e \longrightarrow Ne^{22} (T_{1/2} = 2.6 \text{ years})$$
$$Cl^{35}(\alpha,p)Ar^{38}$$

If uranium is in an environment high in oxygen, the O^{18} (α,n) reaction would predominate. The neutron yield in normal oxygen from polonium alpha rays is reported by Roberts (*11*) to be 3×10^{-5} neutron per alpha particle. Morrison (*12*) quotes yields, in typical rocks, which reflect the energy of the various alpha particles in the radioactive series, of 1×10^{-6} neutron per alpha particle for uranium and 2×10^{-6} neutron per alpha particle for thorium. With eight alpha particles per uranium atom, the rate of production of xenon from fission of uranium-235 is 10^{-6} times the rate from spontaneous fission.

Even five billion years ago, when the abundance of uranium-235 was 100 times its present abundance, thermal neutron fission did not compete with spontaneous neutron fission.

Decay of iodine-129. Iodine-129 is unstable, with a measured half-life of 1.7×10^{7} years (*13*), decaying into xenon-129. Previous speculations (*13*) concerning excess xenon-129 in the earth's atmosphere have been directed to determining the interval between the formation of the elements of which the solar system is composed and the establishment of a gravitational field capable of holding the earth's atmosphere.

On the assumption of an original iso-

Table 2. Spontaneous fission production of krypton and xenon.

Depth of surface layer (cm)	Krypton		Xenon	
	Total No. of atoms	Pressure (atm)	Total No. of atoms	Pressure (atm)
10^{2}	1.5×10^{25}	9.1×10^{-20}	2.5×10^{26}	1.4×10^{-18}
10^{4}	1.5×10^{27}	9.1×10^{-18}	2.5×10^{28}	1.4×10^{-16}
10^{6}	1.5×10^{29}	9.1×10^{-16}	2.5×10^{30}	1.4×10^{-14}

topic abundance of iodine-129 equal to that of iodine-127 of 0.014 per 10,000 atoms of silicon (*14*) and of a composition of the moon approximately that of the earth's mantle, there should be 5.6×10^{23} atoms of iodine-127 per centimeter of surface layer. The same number of atoms of iodine-129 should originally have been present.

If the observed atmosphere consists of 4×10^{21} atoms of xenon-129, this must once have been iodine-129, in a surface layer which has been outgassed after radioactive decay to xenon. Under the assumption that the astronomical body as we know it was formed immediately after the formation of the elements, the layer required to produce the present atmosphere is 0.015 centimeter. In view of the cataclysmic processes which produced the craters, this is an unrealistically small surface layer.

The other extreme assumption is the release of all xenon and the loss, through escape, of all but 4×10^{-10} of the original xenon-129. This requires communication with the interior several tens of millions of years after element formation, since this interval is required to permit the decay of the iodine. It is doubtful whether a model could be devised, which resembles the moon, which would permit of total degassing. With present values of the surface temperature and gravitational field, no mechanism seems to be available for the escape of these heavy gases.

On the basis of different thicknesses of the surface layer, which has been completely outgassed, values of the interval between element formation and the creation of the astronomical object in its present form may be derived and are shown in Table 3.

Table 3. Relation between surface layer outgassed and interval between element formation and satellite formation.

Depth of surface layer (cm)	$t \times 10^{-8}$ (years)
1	1.2
10	1.8
10^3	2.9
10^5	4.0
1.7×10^5	5.6

After planet formation for a period of at least 10^7 years, a mechanism must exist for outgassing the surface layer. It would be surprising if collisions with meteors, responsible for the craters, did not occur over such a period.

If we assume the *maria* to represent melted (and outgassed) rock, and if we assume the outgassing of the fragmented debris from the collision, an estimate can be made of the depth of excavation represented by present craters. A value between 10^4 and 10^6 centimeters would appear probable.

On this basis, the period of satellite formation would appear to be 4×10^8 years, during which time a low gravitational field and perhaps turbulent diffusion combined to rid the material of all rare gases. After establishment of a body with the present gravitational field and poor communication with the interior, the surface layer was disturbed and outgassed for a period of at least the order of a half-life. Thereafter, the body may have been completely quiescent. These conclusions would appear to agree with the analysis of Urey concerning the sequence and duration of events in the early history of the moon.

Primeval gases. If there were no mechanism for producing krypton and xenon, some primeval gas might still be present. An analysis of the concentrations in the atmosphere and rocks of the earth may give some rough magnitudes for the moon. The assumptions on which the extrapolations are based are: (i) the earth and moon have a common origin; (ii) xenon and krypton do not enter into chemical combination; (iii) on the basis of present assumptions relative to the temperature and mass of the moon, negligible amounts of the gases are currently lost. It is felt that if the physical states of temperature, mass, and material do not differ too greatly, the following figures may hold.

Brown (*15*) has inferred that the rare gases escaped during planet formation by comparing amounts found in the earth's atmosphere with estimates of the universal abundance. He has measured the concentration of neon and argon in the atmosphere, in natural gases, and in rocks, as well as the concentration of krypton and xenon in atmosphere and natural gases. He infers that 1.6×10^{-11} and 2×10^{-12} are the abundances, by weight, of krypton and xenon in rock. If these concentrations are assumed for lunar rock, the values in Table 4 result.

Table 4. Estimate of concentrations of rare gases in lunar rock, based on concentration in terrestrial rocks.

Depth of surface layer on moon (cm)	Krypton		Xenon	
	Total No. of atoms	Pressure (atm)	Total No. of atoms	Pressure (atm)
10^2	10^{21}	6×10^{-12}	7×10^{20}	6×10^{-14}
10^3	10^{22}	6×10^{-12}	7×10^{20}	6×10^{-13}
10^4	10^{23}	6×10^{-11}	7×10^{21}	6×10^{-12}

For reasonable values of the layer excavated by meteors (10^4 to 10^6 centimeters), the predictions exceed observations by a factor of more than 100. It is certainly permissible to assume increased loss of rare gases, by the necessary factor, over the loss occurring on the earth. However, samples studied on earth have, at one or more times, been affected by geological processes in the surface layer of the crust and may well have received their rare gases from the atmosphere. These occluded gases may not, therefore, be primitive in the sense that their history is independent of the earth's atmosphere.

The only other cosmic material we can subject to analysis is meteoritic material, which contains no measurable quantities of rare gases. It is therefore difficult to decide whether the analogy of the moon with the earth or of the moon with meteorites is the more valid.

Discussion

Three mechanisms appear to be adequate to account for the radio astronomy observations: (i) spontaneous fission of uranium-238, (ii) xenon-129 from iodine-129, (iii) primeval gases. A priori

Table 5. Composition of lunar atmosphere (by volume).

Gas	Spontaneous fission	Iodine-129	Primeval gas
Krypton-78			0.003
Krypton-80			0.021
Krypton-82			0.118
Krypton-83	0.002		0.108
Krypton-84	0.007		0.530
Krypton-86	0.047		0.162
Xenon-124			0.000006
Xenon-126			0.000006
Xenon-128			0.0013
Xenon-129	0.0007	1.0	0.018
Xenon-130			0.0027
Xenon-131	0.029		0.0143
Xenon-132	0.224		0.0182
Xenon-134	0.314		0.0071
Xenon-136	0.378		0.006

spontaneous fission is a certain mechanism which is quantitatively insufficient. However, by assuming sufficient segregation of uranium in the surface layer, this defect can be corrected. The mechanism involving residual primeval gases is based on analogy with the earth and is quantitatively too large. If a correction factor is applied to this mechanism, there is no good reason for not accepting data from meteors, which give values much too small.

The previous existence of iodine-129, while a matter of speculation, is well founded on present theories of element formation. If we accept this assumption, it is then possible to estimate the interval between element formation and the formation of the satellite in its present state. The interval of 4×10^8 years would not appear to be contradicted by other observations.

The three alternatives lead necessarily to explicit predictions of the composition of the lunar atmosphere. These are given in Table 5. If iodine-129 is alone responsible, there will be only xenon-129; if spontaneous fission, there will be 5 percent krypton and 95 percent xenon; if primeval gases, 93 percent krypton and 7 percent xenon.

It would appear that only a gas sample would make it possible to distinguish between the alternatives. Since the scale height is only a few kilometers, it is not probable that initial grazing rocket orbits would come sufficiently close to permit the collecting of a gas sample.

References

1. B. Elsmore and G. R. Whitfield, *Nature* **176**, 457 (1955); C. H. Costain, B. Elsmore, G. R. Whitfield, *Monthly Notices Roy. Astron. Soc.* **116**, 380 (1956).
2. B. Elsmore, private communication; *Phil. Mag.* **2**, 1040 (1957).
3. H. C. Urey, *The Planets* (Yale Univ. Press, New Haven, Conn., 1952).
4. G. P. Kuiper, in *Atmosphere of the Earth and Planets* (Univ. of Chicago Press, rev. ed., 1952), p. 308.
5. L. Spitzer, "The terrestrial atmosphere above 300 KM," in *Atmosphere of the Earth and Planets* (Univ. of Chicago Press, rev. ed., 1952), p. 240.
6. J. Macnamara and H. G. Thode, *Phys. Rev.* **80**, 441 (1950).
7. G. W. Wetherill, *ibid.* **92**, 907 (1953).
8. H. C. Urey, *Proc. Natl. Acad. Sci. U.S.* **41**, 127 (1955).
9. R. Soberman, *Phys. Rev.* **102**, 1399 (1956).
10. G. W. Wetherill and M. G. Inghram, *Nuclear Processes in Geological Settings Conference, Williams Bay, Wisconsin, Sept. 21–23, 1953* (Natl. Research Council, Natl. Acad. Sci., and Natl. Sci. Foundation).
11. J. H. Roberts, *U.S. Atomic Energy Comm. Rept. MDDC 131* (1944).
12. P. Morrison and J. Pine, *Ann. N.Y. Acad. Sci.* **62**, 69 (1955).
13. S. Katcoff, O. A. Schaeffer, J. M. Hastings, *Phys. Rev.* **82**, 688 (1951).
14. H. E. Suess and H. C. Urey, *Revs. Modern Phys.* **28**, 53 (1956).
15. H. S. Brown, in *Atmosphere of the Earth and Planets* (Univ. of Chicago Press, rev. ed., 1952), p. 258.

Louis Pillemer, Immunochemist

The sudden death of Louis Pillemer, on 31 August 1957, came at a time when he had just received wide recognition for his work in the field of immunochemistry.

Dr. Pillemer was born in Johannesburg, Union of South Africa, in 1908, the son of Lithuanian parents. He was brought to the United States at the age of one and was naturalized in 1916. Although he had none of the aids which position and wealth can bestow, he managed to complete his undergraduate studies, in Kentucky, and received his B.S. degree at Duke University in 1932. While at Duke he came under the influence of the late W. A. Perlzweig, who stimulated his interest in biochemistry. On the advice of Perlzweig he came to Western Reserve University in 1935 to continue his studies, working toward a Ph.D. degree, with emphasis in immunology and biochemistry. While Pillemer was at Duke University he became interested in Perlzweig's attempts to purify and to crystallize the enzyme urease. It was then a logical step to continue this work and to study the immunological specificity of the crystallized urease. This work became the basis for his doctoral thesis, in 1938. It was entitled, "Chemical and Immunologic Studies on the Effects of Radiant Energy and of Oxidation on Crystalline Urease."

During his studies in my laboratory at the Institute of Pathology, Western Reserve University, Pillemer's great interest in immunology was readily discovered and fired. He showed great capacity for absorbing and retaining information as well as for sustained concentration at the laboratory bench. He also possessed inductive and deductive potentialities, the latter being dominant. In addition, he had the ability to spend two and even three consecutive nights in the laboratory in order to complete a given unstable preparation, and it was not uncommon for him to do so. During this time he rose from the position of demonstrator of immunology (1938–39) to that of associate professor of immunochemistry (1946–50), and to that of professor of biochemistry in 1950. Throughout these years, Pillemer's time was devoted primarily to research.

Early in his career at Western Reserve he showed great interest in our work on the elusive factor called "complement," an interest he maintained to the last days of his life. Realizing the need for more knowledge of protein separation, and being aware of the beautiful studies then under way in the laboratories of E. J. Cohn at Harvard, we decided, after consultations with Cohn, to send Pillemer to Boston to learn the basic techniques of the Harvard group. Before he left for Boston we were able to show, in collaboration with Chase Breeze Jones, that the complement complex was bound to certain globulins of the serum, but the newer methods of the Boston workers led to the separation and characterization of two of the four components of the complement complex.

In 1944 Pillemer was called to military service and was attached to the Army Medical School in Washington, D.C. Upon his discharge, he returned to Cleveland and undertook the problem of the purification of certain bacterial toxins. The support for these studies came first from John Wyeth and Sons of Philadelphia and then from Lederle Laboratories Division, in New York. By 1946, Pillemer, in collaboration with Wittler,

Burrell, and Grossberg, succeeded in purifying tetanus toxin to the point of crystallization and with high yields in toxicity. Concurrently, Lamanna and his associates, and Abrams and his associates, succeeded in crystallizing the toxin of *Clostridium botulinum* (A). These two toxins were, therefore, the first to be crystallized.

Purification work was extended to formaldehyde-detoxified tetanal and diphtherial toxoids. Partially purified preparations of these immunizing agents soon became commercially available and were also incorporated into diphtheria-pertussis-tetanus "triple vaccine." It was a natural extension of these studies to attempt to isolate the protective antigen of *Hemophilus pertussis* in order that it might be used to supplant the killed-organism vaccine then available. In collaboration with Blum and Lepow, Pillemer separated the antigen by a novel procedure involving sonic disintegration of the organisms followed by adsorption of the protective antigen on human red cell stromata. This preparation was highly effective in protecting mice against *H. pertussis* in the intracerebral challenge test. Furthermore, a beautifully planned and executed field trial, conducted by the British Medical Research Council, has demonstrated the efficacy of the Pillemer antigen in protecting human beings against whooping cough.

The importance of the isolation of the protective antigen of *H. pertussis* transcends its possible use in a purified "triple vaccine." This work has made it possible to show that the protective antigen is distinct from other, previously implicated, antigens, such as agglutinogen; that the protective antigen does not give rise to a demonstrable circulating antibody (this finding rules out any protective effect of agglutinin and other, previously implicated, antibodies); that the mouse intracerebral challenge test, while "unphysiological," is a valid assay for establishing the potency of pertussis vaccines; and finally and perhaps most important, that the mechanism of immunity in *H. pertussis* and related infections remains to be explained.

By 1954 Pillemer had returned to our old problem on complement and, together with his associates—Blum, Lepow, Ross, Todd, and Wardlaw—made an important contribution in the field of natural immunity by demonstrating the existence of, and by isolating, a new serum protein named "properdin" and by demonstrating its role in immune reactions. These workers found that properdin, in conjunction with complement and Mg^{++}, participated in the destruction of certain bacteria, protozoans, and abnormal red cells, as well as in the inactivation of certain viruses. This new protein was found in normal human and other mammalian sera and appeared to be involved in infection and resistance. There was indeed shown to be a relationship between the properdin level and the resistance or susceptibility of experimental animals to infection. Properdin was purified and characterized as a euglobulin with an isoelectric point between *p*H 5.5 and 5.8. It was shown to contain lipid, carbohydrate, and phosphorus and, in the human being, to comprise not more than 0.02 percent of the normal serum proteins. A unit of this agent contains not more than 0.5 microgram of protein nitrogen. The molecular weight of properdin is over 1,000,000. Properdin was shown to differ from antibody in that it combined with various and unrelated substances. For its function it appeared to require the various components of the complement complex. Pillemer, then, considered properdin to be a primordial form of antibody.

Since properdin was originally obtained after adsorption to an insoluble polysaccharide (zymosan) derived from yeast cell walls, a logical extension of these studies was the observation of whether or not polysaccharide complexes of microbial and mammalian origin would combine with properdin and thereby alter properdin levels *in vitro* as well as *in vivo*. This work was done by Pillemer together with Schoenberg, Blum, and Wurz; with Ross; and with Landy and other collaborators. The active polysaccharides contained both alpha and beta linkages, furanosidic and pyranosidic units, and interhexose linkages of 1.4, 1.6, 1.3, 2.1, and 2.6 types, as well as combinations of these within the same component. The properdin system thus comprised: (i) properdin; (ii) complement or factors resembling complement; and (iii) magnesium ions. Its primary role appeared to be in the natural defensive system of the host. Time will clarify this function.

Pillemer belonged to many scientific organizations, among them, the International Society of Hematology. In 1956 he received the R. E. Dyer lectureship award, in Washington, D.C.

He was an incorrigible individualist and cared little for honors. His only "hobby" was the elucidation of the biochemical aspects of immunology. He knew what he was looking for! Bernard once stated that "he who does not know what he is looking for will not lay hold of what he has found when he gets it." His contributions were the result of devotion to his field and of an unflagging industry.

E. E. Ecker
Institute of Pathology, Western Reserve University, Cleveland, Ohio

News of Science

Explorer

The United States launched its first earth satellite, "Explorer," at 10:48 P.M. on 31 January, from Cape Canaveral, Florida. The 30.8-pound space vehicle, which circles the earth every 115 minutes, is a tube 6 feet, 8 inches long and 6 inches in diameter. It is traveling at approximately 18,000 miles an hour in an elliptical orbit that has an apogee of 1587 miles and a perigee of 219 miles. It is carrying instruments for measuring temperature, cosmic rays, and the frequency of meteorite particles. Information is received from the satellite over two radio transmitters that emit a sustained, though varying, high-pitched signal. The higher powered of the transmitters, which has an output of 0.06 watt, can be heard by anyone on a frequency of 108.03 megacycles and is expected to last for two or three weeks. The second transmitter operates with a power of 0.01 watt at 108 megacycles. It probably cannot be heard by amateurs; however, it should last two or three months because it consumes so little power.

Sputniks I and II. The American launching comes 4 months after the U.S.S.R. placed the first earth satellite, sputnik I, in orbit on 4 October 1957, and then sent sputnik II aloft about a month later. Sputnik I, which disintegrated on 4 January, was a 22-inch sphere that weighed 184 pounds, reached a maximum altitude of 560 miles, had an initial period of 96 minutes, and lasted 3 months. Sputnik II is rocketlike in shape, weighs 1120 pounds, reached a maximum altitude of 1056 miles, had an initial period of 103 minutes, and is expected to last for about 5 months. It contained a live dog when it was fired.

Launching vehicle. Explorer was launched with the Army's four-stage Jupiter-C rocket. This is a specially adapted version of the Army Redstone, an artillery weapon that is a descendant of the Nazi V-2 missile of World War II. Ordinarily the Redstone is fueled with oxygen and alcohol, but for the satellite firing liquid oxygen and a new propellant called "hydyne" were used. Hydyne is considered a major development in the field of high-power rocket fuels. It was produced by Rocketdyne, the California firm that built the Jupiter's motors. Wernher von Braun, chief of the Army Ballistic Missile Agency's development operations, and formerly rocket specialist for Germany, was primarily responsible for the successful launching. He described it as follows.

The first-stage Redstone, with its 78,000 pounds of thrust, lifted the 70-foot, 65,000-pound missile assembly to an altitude of 53 miles in 145 seconds. With its fuel exhausted, the first stage dropped off, leaving the three other stages, consisting of clusters of small solid-propellant rockets, to coast on up to an altitude of about 212 miles. For guidance, the last three stages were set spinning on take-off. As they coasted upward, the final three stages gradually arched over until they were moving parallel to the earth's surface. At this point, 405 seconds after take-off, a remote control button was pushed on the ground, firing the three stages in rapid succession and accelerating the satellite to the orbital speed of 18,000 miles an hour. The Explorer then went whirling off into space at a rate of about 700 revolutions a minute.

Explorer was sent up at an angle of 35 degrees to the equatorial plane so that the earth's rotation would give the launching rocket maximum assistance as it rose into space. The two sputniks were inclined to the equator at angles of about 65 degrees. The much shallower inclination of the Explorer's orbit, now calculated at 33 degrees at the equator, means that the American satellite probably will not pass over the Soviet Union.

Visual tracking. Because of its narrow silhouette, Explorer will be more difficult to see than the Soviet satellites. According to Fred L. Whipple, director of the Smithsonian Astrophysical Observatory and head of this country's visual tracking program, there is a 6-degree daily regression to the west in the orbit of Explorer. This will bring it low enough to be visible to the naked eye in the Northern Hemisphere in about 9 months. Whipple says that it will be visible without instruments in the Southern Hemisphere in the next 3 months. He reports that the principal visual tracking will be done with high-powered telescopes at four American stations and at two in South Africa. The stations are at Yuma, Ariz.; China Lake, Calif.; Albuquerque and Alamagordo, N.M.; and Bloemfontein and Capetown, Union of South Africa.

History. The plan for launching an artificial satellite with a multistage system of the Jupiter-C variety dates back to June of 1954. At that time a group of civilian and military scientists, including von Braun, met in Washington and agreed that a 5-pound vehicle could be sent aloft soon by using the Redstone for a first stage and clusters of Loki rockets for three other stages. The group laid plans for a joint venture, Project Orbiter, under which the Army was to provide the missiles, the Navy was to provide the satellite and instruments, and the Air Force was to help with logistics. However, it was never possible to muster enough support to put Project Orbiter into effect, partly perhaps because of interservice rivalries.

Help in stimulating Government interest in satellites came with the maturing of plans for the International Geophysical Year, to run from July 1957 through December 1958. In October 1954 a special IGY committee asked participating governments to consider launching satellites during the 18-month period. In the spring of 1955 the Administration responded, and a committee of nine scientists was created to study proposals put forward by the three services. The Presidential decision for the Navy's Project Vanguard, which was to be purely scientific, was announced in July 1955.

Largely overlooked at the time was the fact that 3 months earlier the Soviet Union had announced a similar satellite project. The United States and the U.S.S.R. have shown one particularly significant difference in the administration of their outer space research. In this country the satellite program has been entirely separate from the missile program, and of much lower priority. The Russians, on the other hand, developed their satellite launching vehicle as part of their military rocket program.

The first rocket firing connected with Project Vanguard, which has been badly hampered by lack of funds, took place in December 1956. The rocket was a Viking, and the test demonstrated that there was serious trouble with components intended for the Vanguard vehicle. As it became evident that Vanguard would be ready later than expected, pressure developed within the Administration to permit the Army to use a Jupiter-C to launch a satellite. When the Soviet Union put up sputnik I, the pressure grew more intense, and when sputnik II was announced the Administration gave in. Nevertheless, the Vanguard was to have first chance at a launching, and on

6 December an unsuccessful attempt was made at Cape Canaveral. Another test on 27 January had to be called off within 14 seconds of time zero because of trouble with the second stage.

The three-stage Vanguard rocket is 72 feet in over-all length, with a maximum diameter of 45 inches. It has an initial thrust of 27,000 pounds and its payload is a globular, 21-pound satellite. Von Braun said in a public statement recently that the Vanguard is superior to Jupiter-C, and that the Vanguard satellite will be pushed by a rocket needing only one-third of the thrust and take-off weight of the more cumbersome Jupiter-C. He commented that Vanguard is at a disadvantage because it is such an advanced rocket:

"It is so sophisticated that it is a little difficult to get it off. Ours is based on older and more proven components. . . . Ours is a little more obsolete."

Not long ago von Braun told the Senate Preparedness Subcommittee that it would take this country 5 years to catch up with the Russians in rocketry.

Bill to Establish AEC Outer Space Division

Proposals to give to the Atomic Energy Commission the job of building nuclear powered space vehicles are incorporated in a bill introduced in the Senate on 23 January by Sen. Clinton P. Anderson (D, N.M.). The bill would amend the Atomic Energy Act to permit the AEC to add to its current responsibilities responsibilities for the necessary research, construction, and operating facilities with which to achieve peaceful control of outer space and interplanetary travel. Anderson, who is vice chairman of the Joint Committee on Atomic Energy and chairman of its Subcommittee on Outer Space Propulsion, points out that by placing the project within the framework of the AEC, the principle of civilian control would be retained and emphasis on peaceful application of knowledge assured.

The bill would create a Special Outer Space Advisory Committee of seven members to be appointed from civilian life by the President, with the advice and consent of the Senate. The bill proposes to establish within the AEC a Division of Outer Space Development which would administer the AEC's activities in this field. The Commission would be required to use to the fullest practicable extent existing Government atomic laboratories and to retain full authority for the "planning, direction and overall budget control" for the program and its projects. To get underway, the bill would authorize the appropriation of $50 million "to finance initial operations and construction" to carry out provisions of the amendment. The bill would "authorize and direct" the AEC to accelerate research and development on outer space propulsion and to negotiate and execute with general policy guidance of the State Department, an agreement with cooperating nations for the establishment of and participation in an International Laboratory for Outer Space Propulsion.

Antarctic Ice Drilling

The deep drilling project at the IGY Byrd Station in Antarctica passed the 1000-foot mark on 26 January, according to a report by the IGY Committee of the National Academy of Sciences. Ice cores taken from this drill hole preserve in their annual layers clues to antarctic climate reaching back many centuries.

The deep drilling program is being conducted for the IGY by personnel from the Army Snow, Ice and Permafrost Research Establishment of the Corps of Engineers. Development of techniques and equipment for deep drilling to obtain undisturbed cores was inaugurated on the Greenland Icecap in 1956 and was continued and improved in 1957. Deep drilling at the Byrd Station was begun last December.

A modified Failing "1500" drill rig and specially-designed core barrels and bits are being used. Ice cuttings are removed from the drill hole by compressed air that has been specially cooled to the required temperature so that the core sample will not be melted. Extreme care must be taken to avoid shattering of the ice cores when they are removed from the great pressure which exists at depths over several hundred feet.

Equipment for the Byrd Station project was brought in by over-land traverse from Little America, 647 miles away. Some equipment was dropped by parachute.

Because of the relatively small annual accumulation of snow in Antarctica, ice at 1000 feet below the surface at Byrd Station is roughly equal in age to ice at the 2000-foot level in Greenland. However, the antarctic cores are more difficult to date. In Greenland, the annual layers of snow are generally marked by a thin crust of refrozen summer melt. The age of a core can then be read as one reads the age of a tree by its annual rings. In the Antarctic, the annual layers are thinner and more closely packed, and there is often little or no summer melt. Careful chemical analysis may be needed to date the deep-lying cores.

The Byrd Station cores will be broken into 3-inch units for density measurements, visual examination, and determination of yearly accumulation whenever possible. Microscopic examination and photography of thin sections of ice at different depths will permit studies of crystal structure and more accurate relation of age to depth. Selected portions of the cores are to be melted and filtered for study of the minute particles and primitive organisms that may have been trapped in the ice for hundreds of years.

Volcanic ash from the eruption of Katmai in 1912 has been found in cores taken from the Greenland ice, and it is expected that similar ash and other matter, perhaps from much earlier periods, will be found in the Byrd Station cores. A similar drilling project is planned for the Ross Ice Shelf in the latter part of this year.

Science Talent Search

Forty high school seniors were recently named winners in the 17th annual Science Talent Search, which this year attracted a total of 25,039 applicants, the largest number in the history of the competition. Each of the winners, 8 girls and 32 boys, has been awarded an all-expense trip to Washington, where they will compete for $34,250 in scholarships and awards during a 5-day Science Talent Institute beginning 27 February.

In this year's search, New York continued to lead all states in the number of winners produced—eight boys and one girl. Six of the nine come from New York City and vicinity. Illinois and California tied for second place with four each. Massachusetts placed third with three.

Begun in 1942, the Science Talent Search is conducted by Science Clubs of America through Science Service. The Westinghouse Educational Foundation, supported by the Westinghouse Electric Corporation, provides the awards and makes the Science Talent Search financially possible. Because of an expanded grant from the Westinghouse Educational Foundation, the total value of the scholarships and awards presented this year will amount to more than triple the $11,000 distributed each year in the past.

Underground Nuclear Test

The Atomic Energy Commission has reported that the yield of the deep underground nuclear test conducted at the AEC Nevada Test Site in September 1957 was 1.7 kilotons [*Science* **126**, 200 (2 Aug. 1957); **126**, 554 (20 Sept. 1957)]. Heretofore, data on such tests have been highly classified. Now the AEC has released full details for the benefit of seismologists, geophysicists, and geologists.

The shot was detonated at 09 hours,

59 minutes, 59.45 seconds Pacific Daylight Time (16:59:45 GCT) on 19 September at the end of a tunnel about 2000 feet long dug horizontally into the side of a mesa at the northern edge of the Yucca Basin. The explosion took place in a layer of volcanic tuff. The coordinates of the detonation point were: latitude 37° 11′ 44.8″ N., longitude 116° 12′ 11.3″ W., elevation 6615 feet above mean sea level. The vertical distance from the detonation point to the mesa surface was 899 feet, and the slant distance to the side of the mesa was approximately 800 feet.

Grants, Fellowships, and Awards

Jet Propulsion. The Daniel and Florence Guggenheim Foundation has announced that from 18 to 20 Daniel and Florence Guggenheim fellowships will be awarded in 1958 to outstanding graduate students residing in the United States and Canada for study at the Daniel and Florence Guggenheim Jet Propulsion Centers at Princeton University and California Institute of Technology, and at the Institute of Flight Structures at Columbia University. The awards carry stipends of $1500 to $2000 each, plus tuition. Application forms are available at each of the institutions named and at the Daniel and Florence Guggenheim Foundation, 120 Broadway, New York, N.Y.

Radiation. A David Anderson–Berry Medal, together with a sum of money amounting to not less than £100, will be awarded in 1958 by the Council of the Royal Society of Edinburgh for recent work on the effects of x-rays and other forms of radiation on living tissues. Published work will be taken into consideration if it is submitted to the society with the application. In addition to direct application for the prize, proposals may be made on behalf of others. Applications and proposals must be received before 31 March by the General Secretary, Royal Society of Edinburgh, 22,24 George St., Edinburgh 2, Scotland.

Lilly Converts to Metric System

In January 1957 Eli Lilly and Company, pharmaceutical firm in Indianapolis, Ind., discontinued the avoirdupois system of weights and measures and converted all operations to the metric system. The United States and Great Britain are the only civilized countries in the world which still have not adopted the metric system for commercial use, despite the simplicity of calculation it provides.

Thomas Jefferson recognized the advantages of the metric system as long ago as 1790 and recommended that Congress introduce the system in this country; Congress failed to act. John Quincy Adams made a similar unsuccessful proposal to Congress in 1821, and it was not until 1866 that legislation was passed that made the metric system legal.

In the October 1957 issue of the *Hoosier Purchasor,* Lilly spokesmen describe the company's conversion to the metric system as follows:

"We found the 90-year-old roots of the avoirdupois system quite difficult to sever. . . . [However,] there was enough agitation among our scientific personnel to cause management to decide that it might be advantageous if the entire plant operated on only one weights and measures system instead of the five systems in existence—metric, avoirdupois, apothecary, avoirdupois and apothecary combined, and decimal avoirdupois.

"This led to the establishment of a committee with all groups concerned represented. The committee was under no pressure . . . allowing ample time to study all phases of the program thoroughly over a period of several years.

"One of the first actions of the committee was to request that a half dozen formulas in each product group, that is ampoules, tablets, liquids, capsules, etc., be revised to show both avoirdupois and metric on the manufacturing formula used in dispensing and production. . . . When our men in the dispensing group saw that instead of measuring out 1 gallon, 2 pints, 3 fluid ounces, 2 fluid drams, and 50 minims of a liquid they would merely have to measure 4920 cc. in the metric system, they were sold at once. . . .

"One problem the committee had to face was how to accomplish such a conversion program economically. We had about 2500 manufacturing formulas . . . which required revision. . . . The approximate cost of a revision . . . is about $50. Therefore, to revise all formulas to metric, specifically for that purpose alone, the cost would have been nearly $125,000. . . . Finally it was decided that all manufacturing formulas would be rewritten to show both the avoirdupois and the metric systems. Under this setup the use of the avoirdupois system would be dropped at the time of conversion to metric, but the avoirdupois figures would still show on our formulas. However, the rewriting was only to be done when the formula came up for a routine revision, such as a change in lot size, an alteration of the manufacturing process, [or] a change in assay standards. . . . This was, therefore, a very long-range program to convert our formulas to express both systems; but we could also assume that it would not cost $125,000. We established a target date of December, 1956, for the completion of this formula revision phase and were able to meet this date. . . .

"As for the purchasing department, we found it was very interesting to attempt to develop sources which would supply us in metric. . . . With only minor exceptions, our suppliers rallied to the challenge and began shipping packages in even metric packages or in standard avoirdupois packages with the metric conversion stenciled on each container. They also complied with our request to invoice in metric. We found that we were not able only to receive fine chemicals in metric, but also carloads of heavy chemicals and tank trucks of solvents, corn syrup, and acids. . . . We now estimate that greater than 90% of our chemical raw materials are coming to us in metric. . . .

"In addition to soliciting cooperation verbally through sales representatives, we prepared an "Important Progress Announcement" which was attached to each purchase order. . . . As an aid to suppliers, we prepared conversion charts for their use. We sent over 100 of these to one company alone. . . .

"Based on our successful venture, we can see no reason why other industries should not take a serious look at the many advantages of the metric system. We will be happy to help anyone toward this goal in any way that we can."

Foreign Technical Information Center

A Foreign Technical Information Center is being established within the Department of Commerce to collect, evaluate, and distribute valuable foreign scientific and technical literature for the use of American scientists and engineers. To finance prompt action on the new project, the department is requesting a special Congressional appropriation of $300,000. (In addition, the President's budget for 1959 includes $1.25 million for the department's Foreign Technical Information program.)

The new program will set up a central clearinghouse in the Office of Technical Services, headed by John C. Green. In announcing the plan, Secretary of Commerce Sinclair Weeks said:

"In recent years, government agencies and private institutions and industries have steadily increased their translation of Soviet magazines, monographs and books. At the present time, however, there is no central agency in the Government responsible for acting as a clearinghouse on all such foreign, technological, scientific and engineering information for the purpose of making it generally available to American scien-

tists, research institutions and the public.

"With the cooperation of the National Science Foundation, comprehensive surveys were undertaken by the department and other federal agencies last year, and the proposed new center is the result of this groundwork. Plans have been worked out for public distribution of information from such organizations as the National Science Foundation, Atomic Energy Commission, the armed services and the intelligence agencies."

Arrangements have been made to obtain from these and other agencies copies of abstracts and translations of foreign technical articles, monographs and books. It is estimated that these will be supplied at an annual rate of 50,000 abstracts and 10,000 complete translations. The items will be catalogued in the OTS library.

A staff of engineer-translators will be added to review and analyze foreign publications and select those of greatest value. There is also to be a scientific advisory committee to assist in the selection. Arrangements will be made for full translations of important articles and studies. Among the materials the engineer-translators will receive are copies of 200 important Russian scientific journals.

The new center will operate a coordination service to eliminate duplication of translating among U.S. public and private agencies and by friendly foreign governments. In its own translation work, the center will concentrate on technology. The cooperation of industry, universities, libraries and commercial translation firms will be sought in feeding information to the center.

Prosecution for Excessive Radiation

New York State's first prosecution of a corporation for exposing employees to excessive radiation ended on 9 January when a suspended sentence was imposed by a police justice on the Canadian Radium and Uranium Corporation in Mount Kisco. The firm, which had pleaded guilty, processes radioactive materials for medical, research, and industrial organizations.

State Labor Department officials brought action against the corporation last summer, charging that it had failed to survey fully the radiation hazards and had permitted excessive radiation. When the sentence was read, the court noted: "There has been no allegation or proof of any kind that the health of any person, either in or out of the plant, has been impaired in any way by the acts of the defendant, or that the health of the community has been in any way disturbed."

Few Aliens Used Specialist Quota

Fewer than 5 percent of the scientists and other skilled persons permitted to enter this country annually under special immigration provisions actually came in as immigrants during 1957. Only 3600 specially skilled immigrants arrived during the year although there were 75,000 so-called "first preference" quota numbers available.

First preference quotas are reserved for persons "needed urgently in the United States because of the high education, technical training, specialized experience, or exceptional ability of such immigrants." People in this category have precedence over all other would-be immigrants to this country.

News Briefs

Atomics International (a division of North American Aviation, Inc.) and Southwest Atomic Energy Associates have concluded an agreement that calls for a $5,354,000, 4-year research and development program by Atomics International to determine the economic feasibility of the advanced epithermal thorium reactor (AETR) concept with a view to the construction of one or more full-scale atomic power plants utilizing this reactor as a source of energy. The Southwest Atomic Energy Associates is made up of 15 investor-owned electric companies in Arkansas, Kansas, Louisiana, Mississippi, Missouri, Oklahoma, and Texas.

* * *

A fire at Saint Francis College, Loretto, Pa., has completely destroyed the college's library, numerous faculty offices, and the biology department. The damages, not including the building, amount to about $500,000. A college spokesman has written: "We would appreciate the gift or loan of slides, models, incubators, in fact anything which the other colleges might want to give to help tide us over a year or two, till we are completely reestablished."

* * *

Workers digging for a school foundation in Cairo, Egypt, have unearthed two mummified ostriches believed to date back to 1350 B.C. Kamal el-Mallakh, discoverer of the solar boats at the Pyramids of Giza, said the ostriches were found in Matarich, 5 miles west of Heliopolis, the ancient holy city of the sun cult. Heliopolis is now a suburb of Cairo. Archeologists have discovered other mummified animals, but never before ostriches.

* * *

The Atomic Energy Commission has announced that the university participation portion of the Oak Ridge School of Reactor Technology is being curtailed because many colleges and universities are now offering programs in nuclear science. Contracts with six colleges and universities that provide reactor training have been canceled: Carnegie Institute of Technology; Case Institute of Technology; Northwestern University; University of California, Los Angeles; University of Florida, Gainesville; and Union College.

* * *

The National Bureau of Standards has announced publication of Handbook No. 63 *Protection against Neutron Radiation up to 30 Million Electron Volts*. Neutrons present a special type of radiation hazard. This handbook reflects the thinking of the National Committee on Radiation Protection that the recommended limits for maximum permissible dose of ionizing radiations be substantially lowered. The 88-page pamphlet may be obtained for 40 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

* * *

The Ford Foundation, New York, has announced an appropriation of $4.5 million to establish the Educational Facilities Laboratories, an independent, nonprofit organization concerned with research and experimentation leading to improvements in the construction of school and college buildings. The new agency will also serve as an information clearinghouse. Data on school design, building, and equipment will be available to architects, local school systems, college trustees, and others involved in the nationwide expansion of educational facilities anticipated throughout the country in the next decade.

* * *

The Navy has announced that an instrumented container of yeast will be carried in one or more of the 6-inch test satellites to be launched by Project Vanguard in the next 3 months. The growth rate of yeast on earth has been well established by biologists. By checking on the growth cycles of yeast in a satellite, biologists believe they will be able to obtain information on the effects of space travel on life. The reactions of the yeast will be recorded and radioed back to earth by a miniature telemetering system.

Scientists in the News

BERNARD L. PACELLA, an Italian-American psychiatrist of New York, has been awarded the Cavaliere Ufficiale nell' Ordine al Merito della Repubblica, an Italian Government decoration for special merit in the fields of science, letters, arts, or economics. Pacella has been

on the teaching staff of the College of Physicians and Surgeons, Columbia University, since 1942.

CARL G. HARTMAN, director emeritus of the Ortho Research Foundation, Raritan, N.J., has been elected honorary member of the Anatomical Society of Great Britain and Ireland.

ROBERT REIMANN, until recently chief of internal medicine at the Binghamton City Hospital, Binghamton, N.Y., has taken up his duties as chief of internal medicine at the Shiraz Medical Center, Shiraz, Iran. Reimann, a specialist in viral infections, has been a member of the faculty of Jefferson Medical College, Peking University Medical College in China, and the American University of Beirut in Lebanon.

GEORGE L. WEBSTER, professor and head of the chemistry department at the University of Illinois College of Pharmacy, has been named dean of the college. He succeeds Earl R. Serles, who headed the college for 17 years until his death last March.

LINUS A. ZINK will succeed FRANK B. BREWER as assistant chief medical director for operations in the Veterans Administration, Washington, D.C. Brewer is to retire on 31 March after 41 years of federal service. He has been a medical official with VA and its predecessor agencies since 1921 and has held his present position since 1954.

RALPH W. LEWIS, professor of natural science at Michigan State University, will conduct a year of research in the laboratory of E. B. Chain at the Instituto Superiore di Sanita in Rome, Italy.

JAMES B. KITZMILLER, who has been in the department of zoology at the University of Illinois for 10 years, is the new department chairman. F. B. ADAMSTONE, former head, continues as professor of zoology. The department has recently adopted the chairman-executive committee form of administration in place of the headship.

KARL E. SCHOENHERR, dean of the College of Engineering at the University of Notre Dame, has been appointed technical director of the hydromechanics laboratory at the Navy's David Taylor Model Basin in Washington. He replaces F. H. TODD, who has returned to England as superintendent of the Ship Division, National Physical Laboratory, Teddington. Schoenherr is best known for his work in the frictional resistance of fluids along plane surfaces; his formula was published in 1932.

Scientific visitors to the United States from the United Kingdom are as follows.

CHARLES K. ANDERSON, lecturer in urological pathology at the University of Leeds School of Medicine, Leeds, Yorkshire, England, will arrive in the spring (length of stay not known) to work at Memorial Hospital, New York. He will visit the Armed Forces Institute of Pathology, Washington, for about a month, probably in May.

M. W. PERRIN, chairman of the Welcome Foundation, will arrive in the second half of February. He will spend some time in Washington looking into medical matters.

JAMES D. WATSON of Harvard University has been appointed a George A. Miller visiting professor in the department of bacteriology at the University of Illinois during the period from 13 February to 7 March. He will give a series of lectures on macromolecular replication and cell growth.

GEORGE H. LORDI and EDWIN P. MAYNARD have been named clinical professors emeriti of medicine at the College of Medicine of the State University of New York's Downstate Medical Center in Brooklyn. Lordi and Maynard have been on the faculty of the college and its predecessor, the Long Island College of Medicine, since 1923 and 1925, respectively.

Recent recipients of honorary degrees include the following:

MARTHA M. ELIOT, professor and chairman of the department of maternal and child health at the Harvard School of Public Health, from Wayne State University.

HAROLD C. UREY, distinguished service professor of chemistry in the Enrico Fermi Institute for Nuclear Studies at the University of Chicago, from Wayne State University.

STUART M. SESSOMS, assistant director of the Clinical Center at the National Institutes of Health since early 1954, has been appointed assistant director of the National Cancer Institute. He succeeds WILLIAM S. BAUM, who has been transferred to the Public Health Service's Division of Indian Health at Phoenix Ariz., as assistant area medical officer for hospital and medical care.

ALPHONSE R. DOCHEZ, now retired from the department of medicine at Columbia University, recently received the New York Academy of Medicine Medal for distinguished service in medicine. He is well known for his work on the immunochemistry of the pneumococcus and on the etiology of the common cold.

JAMES R. SHAW, chief of the Public Health Service's Division of Indian Health, has been named an assistant surgeon general.

Recent Deaths

WILLIAM B. BAER, New York, N.Y.; 55; dean of New York University's College of Arts and Science in the Bronx; 21 Jan.

JOSEPH V. F. CLAY, Philadelphia, Pa.; 74; emeritus professor of otolaryngology at Hahnemann Medical College and Hospital; 23 Jan.

ERICH DANZIGER, Jackson Heights, N.Y.; 68; research chemist for American Home Products Company; with I. G. Farben in Germany for 25 years before emigrating to the United States in 1937; 25 Jan.

ABRAHAM FABIAN, New York, N.Y.; 48; practicing psychoanalyst and clinical professor of psychiatry at the State University of New York College of Medicine, Brooklyn; 19 Jan.

GRACE LANGFORD, New York, N.Y.; assistant professor of physics at Barnard College from 1906 until her retirement in 1937; 4 Dec.

ROBERT E. LUCE, New York, N.Y.; 46; assistant professor of mathematics at Rutgers University; previously taught at the College of William and Mary, Norfolk, Va., branch; 20 Jan.

PERCY E. MILLER, Philadelphia, Pa.; 59; head of the science department at Girard College; formerly taught night and summer school at Temple University; 27 Jan.

Marshal CANDIDO MARIANO DA SILVA RONDON, Rio de Janeiro, Brazil; 92; explorer; communications officer in the Brazilian Army; discovered 15 major rivers in Brazil; 19 Jan.

CHARLES ROOS, New York, N.Y.; 57; head of the Econometrics Institute, New York, which he founded; former secretary of AAAS Section K and former AAAS executive officer.

THOMAS SHAW, Hackensack, N.J.; 74; inventor and retired electrical engineer, Bell Telephone Laboratories; holder of 21 patents for his inventions in telephone loading; 15 Jan.

CURT G. VOGT, Brielle, N.J.; 65; retired staff chemist for the Toms River-Cincinnati Chemical Corporation; 4 Jan.

WILLIS R. WHITNEY, Schenectady, N.Y.; 89; former vice president in charge of research, General Electric Company; founder of the General Electric Research Laboratory and its director for 32 years; 9 Jan.

Erratum: The name of Alberto Ruz Lhuillier was misspelled Buz l'Huiller on page 136, column 2, line 31 in the article "Groningen Radiocarbon Dates II" by H. de Vries, G. W. Barendsen, and H. T. Waterbolk [*Science* 127, 129 (17 Jan. 1958)].

Reports

Dissimilation of Alfalfa Saponins by Rumen Bacteria

Experimental symptoms of bloat have been produced in sheep by the oral and intravenous administration of alfalfa saponins, demonstrating that saponins have more than one mode of action (*1*). However, the fate of the saponins, the action of microorganisms on them, and the mechanism in the production of bloat are still not known. Recently, Hungate *et al.* (*2*) and Jacobson and Lindahl (*3*) postulated that polysaccharide slime production by ruminal microorganisms might contribute to a stable froth formation which interferes with the normal eructation of fermentation gases in ruminants. The present report presents evidence that alfalfa saponins are utilized by certain rumen bacteria, with resultant production of acids, gas, and large amounts of slime.

Saponin-digesting bacteria were isolated from the rumens of six steers that were being fed a fresh alfalfa diet, by means of modifications of techniques described previously (*4*). Rumen contents were inoculated into two parallel dilution series of 20-percent-rumen-fluid agar shake-tubes, and one series was enriched with 0.5 percent alfalfa saponin. Organisms utilizing saponin were detected by the larger size of the colony as compared with that of the nonsaponin control. Organisms presumed to be saponin bacteria were observed on dilution series from all six animals, with a peak number of 680 million per milliliter of ruminal fluid. Microscopic examination of different colonies showed cells of variable morphology; the predominant type was a small, Gram-negative, curved, motile rod.

Pure cultures of several strains of the bacteria were grown in order to study their characteristics and to obtain quantitative evidence of saponin dissimilation from the chemical analyses of metabolic end products. Fermentation products from the breakdown of 200 mg of alfalfa saponins (*5*) by a representative strain in a yeast-extract peptone medium yielded (in millimoles): carbon dioxide, 1.9; acetic acid, 0.23; butyric acid, 0.15; formic acid, 0.52; lactic acid, 0.14; and traces of ethanol and propionic acid. The organism had a fermentation pattern similar to the atypical strains of *Butyrivibrio* described by Bryant (*6*). Large amounts of slime from the fermentation of saponins were harvested by centrifugation at the end of the incubation period, while scant growth occurred in control medium without saponin.

In the various experiments the dry-weight yield of viscous slime material was approximately 50 percent of the saponin provided as substrate. When the organism was grown on glucose, 10 percent of the substrate appeared as cellular material. Acid hydrolysis of the slime matter gave copious amounts of copper-reducing compounds, indicating its polysaccharide or other glycosidic nature. Heavy froth formation from the microbial degradation of saponins was readily demonstrated in rumen contents containing viable microorganisms, but froth was not produced from the saponins when the bacteria and protozoa were inactivated by mild heat. Rapid gas evolution formed a frothy foam layer 40 mm above the liquid phase 3 hours after 2-percent saponin was administered to rumen ingesta.

Our results support the theory that "frothy bloat" of ruminants maintained on rich forages, such as clover and alfalfa, may be caused by an increase in the production of bacterial polysaccharide slime. The latter forms stable foam in which the rumen fermentation gases are entrapped in the ingesta as numerous small gas bubbles and are prevented from escaping (*2*). In manometric experiments, Hungate (*2*) has observed a correlation between the foam production of rumen ingesta and the intensity of the bloat symptoms of cattle.

The evidence of a rapid microbial decomposition of legume saponins, with the concomitant production of gas and slime, indicates the interaction which exists between the saponins and certain rumen bacteria and demonstrates how these plant compounds may contribute to bloat. In addition, bacterial attack on soluble sugars in the plant materials probably enhances the quantity of slime in the rumen. It is noteworthy that Barrentine (*7*) has had some success in the control of bloat in cattle on rich pasturage through the administration of antibiotics.

JOSE GUTIERREZ
R. E. DAVIS
I. L. LINDAHL
Animal Husbandry Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland

References and Notes

1. I. L. Lindahl *et al.*, *Science* 119, 157 (1954); *U.S. Dept. Agr. Tech. Bull. No. 1161* (1957).
2. R. E. Hungate *et al.*, *Appl. Microbiol.* 3, 161 (1955).
3. D. R. Jacobson and I. L. Lindahl, *Maryland Univ. Agr. Expt. Sta. Misc. Publ. No. 238* (1955), p. 9.
4. J. Gutierrez, *J. Bacteriol.* 66, 123 (1953).
5. The composite alfalfa saponins were furnished through the courtesy of Western Utilization Research Branch and Development Division, Agricultural Research Service, U.S. Department of Agriculture, Albany, Calif.
6. M. P. Bryant, *J. Bacteriol.* 72, 16 (1956); we thank Dr. Bryant for helpful suggestions and other aids.
7. B. F. Barrentine, C. B. Shawver, L. W. Williams, *J. Animal Sci.* 15, 440 (1956).

31 October 1957

Spectral Changes Accompanying Binding of Acridine Orange by Polyadenylic Acid

A recent article by Szent-Györgi and co-workers has cited evidence for formation of a complex between the fluorescent dye acridine orange and the adenine portion of adenosine triphosphate, as well as adenine itself (*1*). In view of this result, it was of interest to examine the interaction of this dye with synthetic polyribonucleotides. This has been done for polyadenylic acid with somewhat unexpected results.

Polyadenylic acid was prepared by the action upon adenosine diphosphate of the nucleotide polymerizing enzyme isolated from *Micrococcus lysodeikticus* by a method described elsewhere (*2*). Spectral and fluorescence studies were confined to concentrations of acridine orange sufficiently low ($< 5 \times 10^{-5} M$) so that the monomer-dimer equilibrium, as studied by Zanker (*3*), is displaced greatly in favor of the monomer. No spectral effect was observed upon addition of adenosine monophosphate. However, a quite marked effect was observed

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

with polyadenylic acid. The addition of increasing amounts of polyadenylic acid to an acridine orange solution in 0.5*M* KCL, 0.01*M* NaOAc, *p*H 6.7, results in a very marked decrease in extinction at $\lambda = 495$ mμ, which also decreases relative to the 465 mμ peak, as Figs. 1 and 2 show. Under the above conditions, the relative decrease in extinction at 495 mμ is almost linear with respect to the mole ratio of adenosine monophosphate to acridine orange, and reaches its limiting value at a mole ratio close to 1:1, as Fig. 1 indicates. If the addition of polyadenylic acid is continued until quite large mole ratios of adenosine monophosphate units to acridine orange (70:1) are attained, the visible spectrum gradually undergoes a second alteration, d_{495} increasing to a relative value of 0.75. In view of the altered shape of the absorption spectrum it is unlikely that the decrease in extinction can be attributed to optical shielding effects alone. It is more likely that it at least partially reflects an altered resonance state of the bound dye molecule.

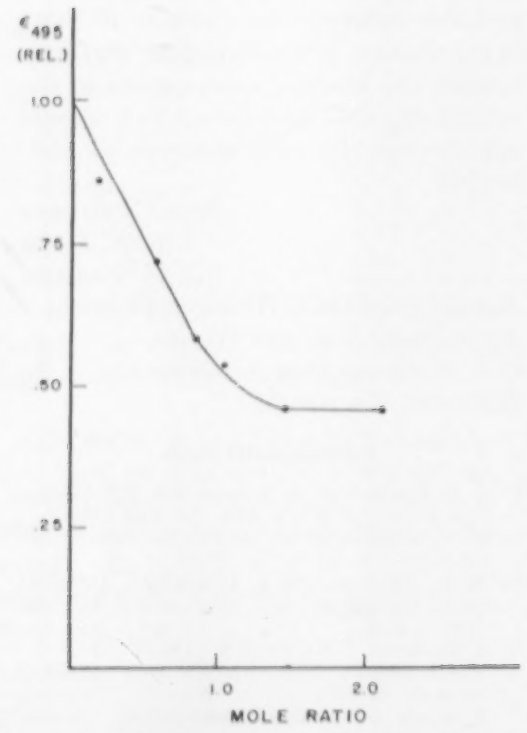


Fig. 1. Effect of addition of increasing amounts of polyadenylic acid to an acridine orange solution of molarity 4.7×10^{-6}. The *p*H is 6.7. The solvent is 0.01*M* NaOAc, 0.5 *M* KCl.

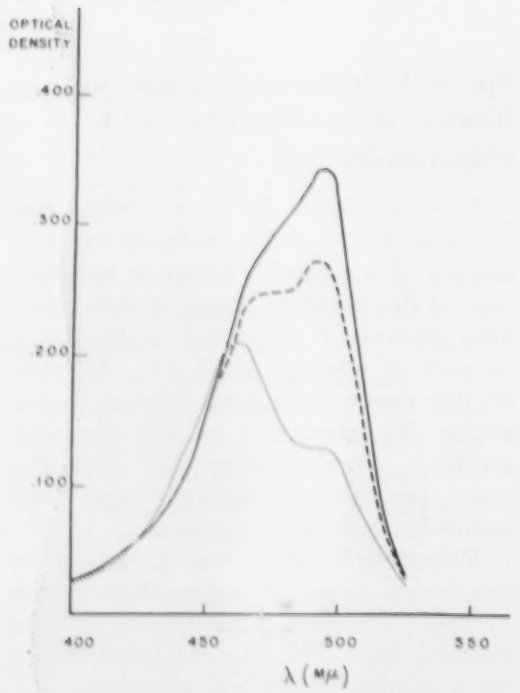


Fig. 2. Effect of increasing addition of polyadenylic acid upon visible spectra of acridine orange. The solvent is 0.01*M* NaOAc, 0.5*M* KCl. The *p*H is 6.7. The molarity of acridine orange is 6.7×10^{-6}. Solid line, no added polyadenylic acid; broken line, $2.6 \times 10^{-6}M$ (adenosine monophosphate units) polyadenylic acid; dotted line, $2.1 \times 10^{-5}M$ (adenosine monophosphate units) polyadenylic acid.

These phenomena were paralleled by a pronounced decrease in the intensity of the fluorescence of the acridine orange ($\lambda_{max.} = 550$ mμ). The intensity of fluorescence decreases to a value of 0.27 relative to that for free dye at about a 1:1 mole ratio of dye to monomer unit (for a total dye concentration of 6.2×10^{-6}) and slowly increases as the nucleotide-dye ratio becomes very large, reaching a relative value of 0.95 at a ratio of 70:1.

Pretreatment of the polyadenylic acid by formaldehyde according to the method of Fraenkel-Conrat results in abolition of both the spectrophotometric and fluorescence quenching effects (*4*).

The preceding results are consistent with the conclusion that acridine orange is bound in a one-to-one manner by the constituent adenosine monophosphate units of polyadenylic acid at low nucleotide-dye ratios. The subsequent alteration of the spectral and fluorescence behavior at high nucleotide-dye ratios reflects the competitive formation of a second complex, favored by the sharing of bound dye by an excess of polyadenylic macromolecules.

In view of the abolition of the spectral and fluorescence effects by blocking the 6-amino group of adenine with formaldehyde and by titration of the adenine groups, it appears that the adenine ring is probably involved in the interaction process. These results thus provide additional evidence for the availability of the adenine group of polyadenylic acid at alkaline *p*H's, as suggested earlier (*4*). In contrast, deoxyribonucleic acid isolated from *M. lysodeikticus* gave no spectral change.

These effects are of considerable interest in view of the known properties of acridine orange as a vital stain and bactericidal agent (*5*).

ROBERT F. STEINER
Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland

ROLAND F. BEERS, JR.
Childrens Hospital School, Baltimore, Maryland

References and Notes

1. K. Karreman, H. Muelle[illegible] A. Szent-Gyorgyi, *Proc. Natl. Acad. Sci. U.S.* 43, 373 (1957).
2. R. F. Beers, Jr., *Nature* 179, 790 (1956).
3. V. Zanker, *Z. Physik. Chem. (Leipzig)* 199, 225 (1952).
4. R. F. Beers and R. F. Steiner, *Nature* 179, 1076 (1957).
5. The opinions expressed here are ours and are not to be construed as official or as reflecting the views of the Navy Department or the naval service at large.

23 October 1957

Use of Mononitrophenols Containing Halogens as Selective Sea Lamprey Larvicides

The invasion of the upper Great Lakes by the sea lamprey and its destructive attacks upon important fishes have engendered a considerable effort to control the numbers of this predator. Means for combating this pest may be applied effectively and economically during those parts of its life-cycle that are spent in streams (*1*). Destruction or diversion of the adults during their spawning runs (the terminal stage of the life-cycle) is a practicable procedure. This is being accomplished by electrical barriers which kill, or repel, the adults before they reach the spawning grounds (*2*). A serious shortcoming of this control technique is the time lag which occurs before the effect of such measures can become apparent. At least six generations of larval lampreys, already resident in stream habitats, continue to grow, transform into adults, and migrate into the lakes to begin their existence as parasites. Thus it may be as much as seven years before the lamprey population of a lake basin shows any marked decrease after the blocking of all streams suitable for spawning.

The life-cycle of the sea lamprey may also be broken effectively at the larval stage by the regulated application of selectively toxic chemicals. This treatment of streams inhabited by sea lampreys should produce more immediate control of the species than is being achieved by present techniques. In the course of screening various chemicals in a search for selective sea lamprey larvicides (*3*), we discovered six mononitrophenols containing halogens which are significantly more toxic to sea lamprey larvae than to other aquatic organisms (*4*). We also found that the conversion of four of these substances to their respective sodium salts increases their general utility without significantly affecting their useful biological activity (Table 1).

Laboratory experiments were conducted in 10-lit glass battery jars, each containing 5 lit of water. These vessels were aerated by means of standard stone air-breakers and were maintained at a constant temperature by immersion in

specially constructed troughs. Test animals in each experiment were larvae of the sea lamprey (*Petromyzon marinus*) and fingerlings of at least two of the following species of game fishes (choice of the species of game fishes depended on availability): rainbow trout (*Salmo gairdneri*), brown trout (*Salmo trutta*), and bluegill sunfish (*Lepomis macrochirus*). To each test container we added two specimens of the species chosen to be exposed to a chemical. Appropriate amounts of the compound were then added to the test jars to produce a desired concentration. Generally, 24 simultaneous replications were run with the same species at each such concentration. All laboratory tests were conducted for a 24-hour period at a water temperature of 55 ± 1°F.

The specific toxic effects displayed by the compounds studied under these controlled conditions are summarized in Table 1.

Our principal objective has been to locate chemicals which are acutely toxic to larval sea lampreys at low concentrations and which, at the same concentrations, are not toxic to other fishes inhabiting the same stream environments. A further requirement was that these selectively toxic materials should be capable of destroying the larvae in a relatively short period of time. We believe that the differential toxicities displayed by these mononitrophenols (with the exception of that exhibited by 5-chloro-2-nitrophenol) cover a sufficiently broad range of concentrations to permit their regulated application in natural streams to destroy lamprey larvae without concurrent damage to other fish. Requirements for a short treatment period are likewise met by these compounds. At minimum effective concentrations of each of the chemicals, all of the larvae were killed in less than 16 hours. At higher concentrations the time was much less. Several of the compounds killed all of the lampreys in less than 45 minutes without apparent harm to the game fish which remained exposed to these concentrations for 24 hours.

We have also tested 3,4,6-trichloro-2-nitrophenol and 3-trifluormethyl-4-nitrophenol in a running water raceway in which natural stream conditions were simulated. In these cases aqueous solutions of the sodium salts of each of these phenols were applied under conditions where continuous flow required their regulated metering into the "stream" during the entire test treatment period.

The raceway utilized for this purpose was a rectangular concrete trough, 65 ft long, 6 ft wide, and 30 in. deep. Water for the "race" was pumped from Lake Huron; its flow into the experimental "stream" was regulated by a "V" weir. For each test treatment undertaken, an artificial stream bed was constructed on the floor of the raceway with materials taken from the beds of local rivers. Typical stream features such as pools and riffles were reproduced. Test animals were released in the raceway sufficiently in advance of a treatment to allow them to become adjusted to the "stream." Each experimental treatment (at a particular concentration) was conducted for a 24-hour period. The larvicidal compound was metered into the water by an electric, motor-driven, dual-piston, fluid-proportioning device. This machine pumped from a concentrated stock solution of the chemical and delivered the concentrate, slightly diluted with flush water, to a perforated pipe laid on the stream bed at the head of the test stream area.

Table 1. Differential toxic effects among larval lampreys and fishes of certain mononitrophenols containing halogens. Sodium salt is expressed in parts per million of free phenol.

Name and form of compound	Concentration required to kill all lamprey larvae (ppm)	Concentration required to cause significant mortality† among fishes (ppm)		
		Rainbow trout	Brown trout	Bluegill sunfish
2-Bromo-4-nitrophenol				
Free phenol	5	13	11	
Na salt	7	15		
3-Bromo-4-nitrophenol				
Free phenol	5	11		15
5-Chloro-2-nitrophenol				
Free phenol	3	5	5	
2,5-Dichloro-4-nitrophenol				
Free phenol	3	13	7	
Na salt	5	17		
3,4,6-Trichloro-2-nitrophenol				
Free phenol	5	17	15	
Na salt	13	23		
3-Trifluormethyl-4-nitrophenol*				
Free phenol	2	9	7	
Na salt	2	7		

* α,α,α-trifluoro-4-nitro-*m*-cresol. † Mortality of approximately 10 percent of all test animals.

Under conditions that simulated treatment of an actual stream, the toxic effects of each of the substances upon fishes seemed to be considerably less than the effects which were observed under laboratory-jar test conditions. On the other hand, concentrations of the materials lethal to all larval lampreys were essentially the same in the jar tests and in treatments of the simulated stream.

For example, in raceway tests of 3,4,6-trichloro-2-nitrophenol (applied as an aqueous solution of its sodium salt), all lamprey larvae were killed by concentrations as low as 12 parts per million. Sustained exposure to a concentration of 40 parts per million of the compound (the highest concentration that we applied experimentally) did not cause any significant toxic symptoms to appear among either rainbow trout or brown trout. Furthermore, exposure to this concentration did not cause any evident harm to any of the following additional test species: brook trout (*Salvelinus fontinalis*), rock bass (*Ambloplites rupestris*), bluegill sunfish, pumpkinseed sunfish (*Lepomis gibbosus*), lake chubs (*Couesius plumbeus*), northern creek chubs (*Semotilus atromaculatus*), logperch (*Percina caprodes*), crayfish (*Cambarus* spp.), dragonfly larvae (Anisoptera), and caddisfly larvae (Trichoptera). Several other species of fishes used in the raceway tests displayed some susceptibility to the higher concentrations of the chemical which we introduced. Yellow perch (*Perca flavescens*) and white suckers (*Catostomus commersoni*) were not affected by a concentration of 32 parts per million, but significant mortalities among these two species occurred during the application of a concentration of 40 parts per million. A considerable number of mortalities occurred among bullheads (*Ictalurus melas* and *I. nebulosus*) during all applications of concentrations of 20 parts per million or more of the phenol.

A comparable accentuation of the selectively toxic properties of 3-trifluormethyl-4-nitrophenol was observed when treatments with this chemical were conducted in our raceway. The results we obtained in our raceway tests with both compounds suggest that all of the mononitrophenols we have studied may be more useful for treatment of actual streams than could have been anticipated from our laboratory-jar tests (*5*).

VERNON C. APPLEGATE
JOHN H. HOWELL
U.S. Fish and Wildlife Service, Rogers City, Michigan
MANNING A. SMITH
Department of Chemistry, Bucknell University, Lewisburg, Pennsylvania

References and Notes

1. V. C. Applegate and J. W. Moffett, "The sea lamprey," *Sci. American* 192, No. 4, 36 (1955).
2. L. F. Erkkila, B. R. Smith, A. L. McLain, "Sea lamprey control on the Great Lakes–1953 and 1954," *U.S. Fish Wildlife Serv. Spec. Sci. Rept. Fisheries Ser. No. 175* (1956).
3. V.C. Applegate *et al.*, "Toxicity of 4,346 chemicals to larval lampreys and fishes," *U.S. Fish Wildlife Serv. Spec. Sci. Rept. Fisheries Ser. No. 207* (1957).

4. We are indebted to the following organizations for preparing and supplying chemical samples and for technical advice in the development of these materials for our specific use: The Dow Chemical Company; Progressive Color and Chemical Company; Diamond Alkali Company; Niagara Chemical Division, Food Machinery and Chemical Corporation; Monsanto Chemical Company; Michigan Chemical Company; chemistry department, Bucknell University; and chemistry department, University of Michigan.
5. This work was supported, in part, by the Great Lakes Fishery Commission.

21 October 1957

Convenient pH Stat Reaction Vessel for Small Volumes

In a series of studies in our laboratory with the *p*H stat of Jacobsen and Léonis (*1*), it became clear that the conventional beaker type of reaction vessel had several disadvantages, the main one being an irreducible minimum solution volume of about 5 to 6 ml, which is an important limiting factor in studies with precious proteins and peptides. The diameter of the beaker and, hence, its volume could not be reduced because of the large number of accessories dipping into it—the glass and calomel electrodes, external stirrer, nitrogen inlet, and others. We have overcome this problem by using a rotating test tube as the reaction vessel with a stationary, concentric glass and calomel electrode assembly (Radiometer No. GK2021). Excellent stirring, with a complete absence of foaming in protein solution, is achieved by the shearing forces between the test tube and the stationary electrode assembly, and volumes may be reduced to 1.0 ml.

As may be seen in Fig. 1, the glass test tube is housed in a Plexiglass rotor fitted with turbine blades. Both rotation of the turbine and temperature control are achieved by a small centrifugal pump which circulates water, from a thermostatically controlled bath, through a jet impinging on the turbine blades. The electrode assembly is raised and lowered by means of a rack and pinion (fitted with a stop to safeguard the electrode bulb). Only a single polyethylene capillary for delivery of acid or base dips into the reaction chamber, thus, we have a relatively unencumbered apparatus. In our work, the use of nitrogen has not been necessary because of the very small surface area of the solution, but in more critical work a polyethylene capillary for the delivery of nitrogen could easily be attached to the electrode assembly.

In summary, the following advantages have been found in the use of this reaction vessel: (i) By using a single size of test tube, volumes of 1 to 5 ml are easily accommodated, and with a larger size of tube, volumes can go to 10 ml. (ii) Stirring is rapid, smooth, and steady in rate for long periods of time, the rate being adjustable by restricting the flow through the jet. (iii) Precise temperature control is achieved. (iv) The glass test tubes are easily changed, giving convenience during a series of titrations and constantly clean glassware without the need for dismantling the apparatus.

GORDON H. DIXON
ROGER D. WADE
Department of Biochemistry, University of Washington, Seattle

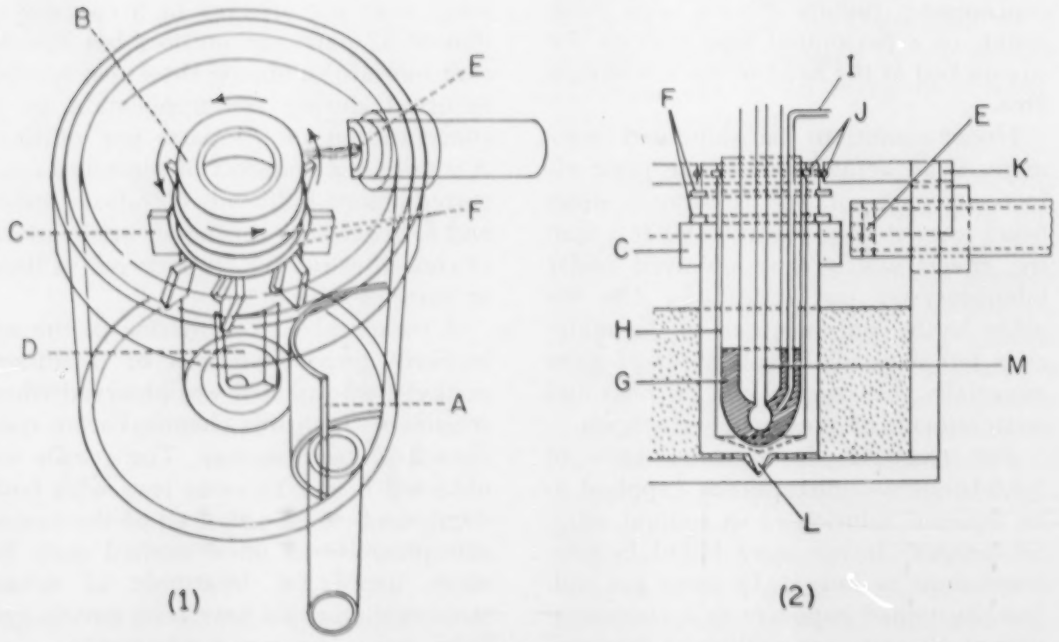


Fig. 1. Apparatus. *A*, Water outlet (designed to act both as a baffle plate and a constant-level device); *B*, rotor (Plexiglass); *C*, turbine blade; *D*, opening in rotor to facilitate rapid temperature equilibration; *E*, jet; *F*, baffle plates to prevent splashing; *G*, reaction mixture; *H*, test tube (glass); *I*, polyethylene capillary for delivery of acid and base from syringe; *J*, Teflon O-rings (the outer ring is a bearing and the inner one is an adaptor for use with various sizes of test tube); *K*, detachable lid; *L*, pivot (the pivot and its bearing should be constructed of stainless steel if extended periods of use are anticipated); *M*, radiometer electrode No. GK2021.

Reference

1. C. F. Jacobsen and J. Leonis, *Compt. rend. trav. lab. Carlsberg Ser. chim* 27, 333 (1951).

31 October 1957

Correlation of Potassium-40 Concentration and Fat-Free Lean Content of Hams

A rapid, objective, and nondestructive method for determining the amount of lean meat present in live animals, carcasses, and cuts of meat should prove to be of considerable value in improving the pricing efficiency involved in the marketing of livestock and meat. Objective evaluation of the amount of lean present would make it possible to set a price that would better reflect the desirability of the product from the consumer's standpoint. In addition, such a technique should help to speed the development of better grade animals for butchering, since accurate nondestructive measurements of the lean content of live animals would aid in the selection of breeding stock.

The research of Woodward *et al.* (*1*) demonstrated that the potassium content of human beings, as determined by measurement of potassium-40 (K^{40}) gamma activity by means of the Los Alamos "human counter" (*2*), was related to the body water content and, therefore, to the lean body weight of the subjects. In view of these findings, it was considered desirable to evaluate the usefulness of the K^{40} concentration as an index of the amount of lean in meat products. Since Federal pork carcass grades (*3*) are based to a considerable extent upon the degree of fatness and the proportion of lean cuts, it was decided to use hams in the study described in this report.

Fresh hams were obtained from the Animal and Poultry Husbandry Research Division of the U.S. Department of Agriculture's Agricultural Research Center at Beltsville, Maryland. One pair of hams (group A) was selected on the basis of their rather fat appearance, while the other pair (group B) appeared to contain considerably less fat. The visible portion of external fat of the hams of group A ranged from 1.2 to 1.8 in. in thickness, while the corresponding range for group B was 0.9 to 1.0 in. The hams were frozen and transported to the Los Alamos Scientific Laboratory, where the following K^{40} measurements were made

on the "human counter." The K^{40} content of group A, of group B, and of both groups together was determined. Apparently, the positioning of the hams in the counter was not of critical importance, since the total number of gamma rays per second recorded for the individual pairs of hams, after the appropriate correction had been made for background depression (21.99 and 22.29 gamma rays per second), agreed closely with the value obtained when all hams were counted simultaneously (44.3 gamma rays per second).

After the K^{40} values for the intact hams had been obtained, the skin and external fat were removed, and counting data were obtained for groups A and B. Following this, the bone and most of the seam fat were removed, and the remaining lean meat was counted for each group. The amount of crude fat present in the lean was determined (*4*) so that the K^{40} values could be related to the amount of fat-free lean present. The data obtained are presented in Table 1.

The K^{40} activity, in actually measured gamma rays per second, per pound, was obtained by dividing the value obtained for gamma rays per second by the actual weight of the sample in pounds. The K^{40} values were not adjusted by a counting efficiency factor to an absolute basis. These values varied directly with the percentage of fat-free lean present. The correlation coefficient (*5*) obtained for the correlation of these two sets of values is 0.983, indicating that the correlation is significant at the 1-percent level. The values for measured K^{40} gamma rays per second, per pound varied inversely with the percentage of fat present. A correlation coefficient of -0.966 was obtained from these values, indicating a negative correlation which is significant at the 1-percent level. The values for measured K^{40} gamma rays per second, per pound of fat-free lean were derived by dividing the value for gamma rays per second by the weight of fat-free lean in the sample. The average of these values was 1.60, with a relative standard deviation (*5*) of 4.8 percent for the total variability among different samples.

A statistical evaluation was made of the counting error involved in the counting operation (*6*). The relative standard deviation of the counting measurements in tests with pairs of hams in which the samples were counted for 20 minutes and the background was counted for 30 minutes was about 3 percent. When the four hams were counted simultaneously (58 lb of hams), counting of the sample for 13.33 minutes and of the background for 20 minutes gave a K^{40} value with a relative standard deviation for counting error of about 1.9 percent. On this basis, it may be possible to determine the K^{40} content of a 175-pound carcass (with a relative standard deviation for counting error of about 5 percent) by counting the sample for 100 seconds and the background for 200 seconds.

In order to compare the counting efficiency of the "human counter" with that of a crystal detector, the hams of group B were counted individually with an 8- by 4-inch NaI(Tl) scintillator crystal, mounted about 2 in. below the frozen ham, which rested on a piece of plywood 0.25 in. thick. Eight inches of steel shielding surrounded the sample and detector. One ham was counted for 30 minutes; this count was followed by a 30-minute count of the background. The resulting K^{40} peak for this ham was 29.4 net counts per minute, with a relative standard deviation for counting error of about 6.8 percent. The second ham of group B was counted for 60 minutes; this count was followed by a 60-minute count of the background. The resulting counting rate was 34.6 net counts per minute, with a relative standard deviation for counting error of 3.3 percent. A comparison of the counting efficiency revealed that the "human counter" detected about 21 times as many K^{40} gamma rays from hams under the conditions of the comparison made as the crystal detector did. The "human counter" has an additional advantage in that the positioning of the sample is apparently not of critical importance, while, when a crystal detector is used, the position relative to the detector is of great importance.

Table 1. K^{40} values as related to the amount of fat-free lean and fat in samples of fresh ham.

Sample	Measured K^{40} gamma rays per second, per pound	Measured K^{40} gamma rays per second, per pound of fat-free lean	Percentage of fat-free lean	Percentage of fat
		Group A		
Intact hams	0.70	1.50	47.4	40.0
Hams without skin and external fat	1.14	1.64	69.8	16.4
Lean portion	1.30	1.50	86.3	13.7
		Group B		
Intact hams	0.83	1.61	51.7	33.3
Hams without skin and external fat	1.19	1.68	70.6	14.2
Lean portion	1.48	1.68	88.5	11.5
		Groups A and B together		
Intact hams	0.76	1.56	49.4	37.1

ROMAN KULWICH
LOUIS FEINSTEIN
Agricultural Marketing Service, U.S. Department of Agriculture, Beltsville, Maryland
ERNEST C. ANDERSON
Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico

References

1. K. T. Woodward *et al.*, *Nature* **178**, 97 (1956).
2. E. C. Anderson *et al.*, *Nucleonics* **14**, 26 (1956); *IRE Trans. on Nuclear Sci. NS-3* 96 (1956).
3. *U.S. Dept. Agr. Serv. and Regulatory Announcements No. 171* (1955).
4. *Official Methods of Analysis of the Association of Official Agricultural Chemists* (Association of Official Agricultural Chemists, Washington, D.C., 1955), p. 386.
5. G. W. Snedecor, *Statistical Methods Applied to Experiments in Agriculture and Biology* (Iowa State College Press, Ames, 1946), p. 138.
6. C. L. Comar, *Radioisotopes in Biology and Agriculture* (McGraw-Hill, New York, 1955), p. 173.

10 October 1957

Composition of Cardiolipin

In a recent, extremely interesting communication on the composition of cardiolipin (*1*), Macfarlane and Gray have reported results which, although admittedly inconclusive, throw considerable doubt on the correctness of the presently accepted concept (*2*) that cardiolipin is a glycerylglycerophosphate derivative containing three phosphoric acid molecules linking four glycerol molecules, the latter being also esterified with one oleic and five linoleic acid residues. Indeed, Macfarlane and Gray consider that their results suggest that cardiolipin is "not a single compound, but a mixture of similar compounds varying in fatty acids." In view of this suggestion, I report, believing it to be of some interest, the results of a preliminary study in which cardiolipin was separated into a number of chromatographically distinguishable fractions each of which possessed the biological activity, as measured by the cardiolipin flocculation test (*3*), of the unfractionated cardiolipin but which differed in the fatty acid moiety.

Fifteen commercial preparations of cardiolipin (*4*) and three preparations made in this laboratory from ox-heart

muscle (*5*) were chromatographed on a mixture of silicic acid and Celite (*6*) (3:1 by weight). The cardiolipin was adsorbed on the column from benzene, and the column was developed with chloroform containing ethanol (5 percent by volume). The column was extruded, and the zones were made visible by streaking with an alkaline permanganate solution (*7*). The zones were cut and eluted with ethanol, and the eluate was concentrated to dryness under reduced pressure at room temperature. Approximately 50 percent of the cardiolipin was retained at the top of the column and could not be moved down the column with 5 percent ethanol in chloroform. The top zone was therefore rechromatographed, with 20 percent ethanol (by volume) in chloroform as the developer, and then gave additional zones.

Each of the cardiolipin preparations could be separated into a number of fractions. The exact number of fractions, however, was not the same for each preparation and varied from four fractions found in one case to eight in another. All fractions were biologically active (*3*). In every case approximately 20 percent of the material placed on the column was not moved from the top of the column under the conditions of development, and hence there is no reason to suppose that additional fractions could not have been obtained.

Three zones, containing approximately 50 percent of the material placed on the column, were found to be present in each of our preparations. These zones were found in approximately the center of the column when the column was developed with (i) four column lengths (*8*) of chloroform containing 5 percent ethanol (zone 1); (ii) four column lengths of chloroform containing 20 percent ethanol (zone 2); (iii) eight column lengths of chloroform containing 20 percent ethanol (zone 3).

In an attempt to identify the individual acids which might be expected to be present in the cardiolipin of zones 1, 2, and 3, each zone was reduced in ether solution with excess lithium aluminum hydride; after treatment with water in the usual manner, the ether phase was concentrated to dryness, and the resulting oil, which should contain the alcohols corresponding to the acids originally present in the zone, was fractionated by distillation at a pressure of 10 μ.

In each case, only one such alcohol was found in any one zone. The alcohols distilled at the following temperatures: zone 1, 83 to 85°C; zone 2, 118 to 120°C; zone 3, 132 to 135°C. When the three alcohols were mixed together, it was still possible to separate them by fractional distillation. The fractions distilled in the same temperature range.

The undistilled alcohol from each zone was also examined chromatographically. Only one zone was found in each case. A mixture of silicic acid and Celite was used as the adsorbent, and the column was developed with benzene containing 1 percent *t*-butyl alcohol (by volume).

On the basis of carbon and hydrogen analyses, the ultraviolet absorption spectrum, the reaction with maleic anhydride, and the melting point of the alcohol obtained after reduction with hydrogen in the presence of a platinum catalyst (*9*), the alcohols obtained from zones 1 and 2 were tentatively identified as 1-dodecanol (corresponding to lauric acid) and 9,12,15-octadecatrienol (corresponding to linoleic acid), respectively. The alcohol from zone 3 was not identified. Analysis indicated the presence of more than one hydroxyl group.

The results are such as would be expected if the usual preparations of cardiolipin were mixtures in which the components differed in their fatty acid moiety.

FREDERICK A. H. RICE*
Department of Microbiology,
Johns Hopkins University,
Baltimore, Maryland

References and Notes

1. M. G. Macfarlane and G. N. Gray, personal communication at the 366th meeting of the Biochemical Society, London, 19 Oct. 1957.
2. M. C. Pangborn, *J. Biol. Chem.* **168**, 351 (1947).
3. H. Eagle, *The Laboratory Diagnosis of Syphilis* (St. Louis, Mo., 1937), pp. 57–63; *J. Venereal Disease Inform. Suppl.* **22** (1949). I wish to thank Dr. A. G. Osler for performing the serological analyses, and the Whitehall Foundation, New York, N.Y., for financial support.
4. A large number of these preparations were obtained through the courtesy of Dr. S. Rosenberg of the Sylvania Chemical Company, Orange, N.J.
5. M. C. Pangborn, *J. Biol. Chem.* **161**, 71 (1945).
6. The Celite used in this study was No. 535, obtained from the Johns Manville Company, New York, N.Y.
7. L. Zechmeister and W. H. McNeeley, *J. Am. Chem. Soc.* **64**, 1919 (1942); B. W. Lew, M. L. Wolfrom, R. M. Goepp, Jr., *ibid.* **67**, 1865 (1945); **68**, 1449 (1946).
8. One column length is taken to be the volume of developer necessary to just wet all the adsorbent.
9. A. W. Ralston, *Fatty Acids and their Derivatives* (Wiley, New York, 1948).

* Present address: U.S. Naval Powder Factory, Indian Head, Maryland.

6 November 1957

Protective Effect of a Colchicine Derivative in Mice Exposed to X-radiation

The profound effect of colchicine upon mitotic activity has been described in abundant detail (*1*). Results of numerous cytological studies of a combination of colchicine treatment and x-irradiation have also been reported (*1, 2*). We find no references to effects of colchicine on survival of mammals given whole body irradiation, possibly because adverse rather than protective action is anticipated.

Table 1. Data on survival of mice given an intraperitoneal injection of 1 mg of trimethyl colchicinic acid methyl ether *d*-tartrate 24 hours prior to x-irradiation.

Irradiation (r)	No. of mice per group	Percentage that survived (28 days)	
		Control	Treated
900	40	70	98
950	20	25	75
1100	15	0	80
1100	20	0	45
1100*	16	0	56

* 0.5 mg of the colchicine derivative.

The primary object of the study described in this report was to alter the sensitivity of bone marrow to x-irradiation. The provisional assumption was made that the sensitivity of these cells would be reflected in survival of the animal. In principle this appears to be a vast oversimplification, although in practice the neutralization of other variables may leave the desired association in evidence. A less distant relationship may be one between marrow sensitivity and peripheral leucocyte count (*3*).

There does not seem to be convincing evidence that cells in colchicine-induced metaphase are more sensitive to radiation than cells in their normal state, and our expectation slightly favored an increase rather than a decrease in resistance. The mere fact of an increase in survival would not, of course, indicate a specific increase in resistance of colchicine-treated cells in preference to any of a number of other processes which might be responsible, but the first step was to determine whether or not survival would be altered by pretreatment with colchicine.

The present brief report is preliminary in nature. The mice used were (BALB/c × DBA/2) F_1 females 12 to 15 weeks old, kept in individual cages. A Van de Graaff generator, operating at 2.5 Mev; 0.6 ma; HVL, 1 cm of lead; TSD, 1 m; and dose rate, 250–300 r/min was used for irradiation (*4*). [Further details are to be found in (*5*).] The colchicine derivative used was trimethyl colchicinic acid methyl ether *d*-tartrate (N.C.I. No. 1136), some of the characteristics of which have been described by Leiter and his associates (*6*). This was given as an intraperitoneal injection of 1 mg per 20 to 25-g mouse in 0.2 ml of saline, 24 hours prior to irradiation.

As shown in Table 1, survival was considerably better in mice that had been given the colchicine derivative than in controls, the maximum difference being

roughly equivalent to a dose reduction of 20 percent. In five experiments (75 mice), no untreated mice survived as long as 2 weeks after exposure to 1100 r, and in four experiments, only one of 90 mice survived 1000 r. In the experiments described in this report, treatment with the colchicine derivative was more effective than treatment with bacterial endotoxin (*5*), although exact optimal doses have not been established for either compound.

Selective alteration of sensitivity to x-irradiation is of great interest. A determination of whether or not such selective alteration has been accomplished in the experiments described here awaits further study, as does the question of an association between effect on mitosis of marrow cells and survival.

WILLIE W. SMITH

National Cancer Institute,
National Institutes of Health,
Bethesda, Maryland

References and Notes

1. O. J. Eigsti and P. Dustin, Jr., *Colchicine—in Agriculture, Medicine, Biology, and Chemistry* (Iowa State College Press, Ames, Iowa, 1955).
2. M. Levine, *Ann. N.Y. Acad. Sci.* 51, 1365 (1951).
3. A description of these studies and of the results of cytological examination of marrow from serially killed animals is in preparation.
4. We are indebted to Dr. Howard L. Andrews for dosimetry and irradiation, to Ilo M. Alderman and Ruth E. Gillespie for other assistance, and to Dr. Margaret Kelly for data on the toxicity of the colchicine derivative.
5. W. W. Smith, I. M. Alderman, R. E. Gillespie, *Am. J. Physiol.* 191, 124 (1957).
6. J. Leiter *et al.*, *J. Natl. Cancer Inst.* 13, 379 (1952).

1 November 1957

Localization of Generator Structures of Electric Activity in a Pacinian Corpuscle

In a large number of sense organs the afferent nerve ending is enclosed in an adventitious structure, the end organ. The question of what the end organ's function is goes back to the early days of sensory physiology. Is it a link in the chain of events which transduce stimuli into nerve impulses, or does it merely play a passive role in reception? The question is here asked for the case of the Pacinian corpuscle. The end organ of Pacinian corpuscles—namely, the capsule—is large enough to allow its dissection. It consists mainly of a peripheral zone (mean transversal diameter 650 μ) with concentrically arranged lamellae and a thin, more compact inner core (transversal diameter about 25 μ) with bilaterally arranged lamellae enclosing the nonmyelinated nerve ending (*1*). The peripheral zone could be peeled off by dissection under a microscope with dark-field or phase-contrast illumination while the receptor's ability for producing generator and propagated potentials in response to mechanical stimulation was tested. Single Pacinian corpuscles of the cat's mesentery were isolated, and these, together with a length of afferent axon, were set up in a bath containing an oxygenated Krebs solution. Mechanical stimulation of the corpuscle was provided by the finely graded deflections of a piezoelectric crystal (*2, 3*). The arrangement for recording of the receptor's electric activity has been described in previous papers (*3, 4*).

When the capsule's peripheral zone is progressively removed, an increase in threshold for producing propagated impulses in response to mechanical stimuli is usually observed. But otherwise no significant changes in the mechanoreceptor properties of the corpuscle are found. The capsule can be peeled off, leaving the inner core exposed without causing impairment of the receptor's ability to produce generator and propagated potentials. It would appear therefore that the peripheral zone, which amounts to about 99 percent of the corpuscle's entire structure, is not required for mechanoreception (Fig. 1).

Due to the intimate relation between the inner core and the nerve structures, it was not possible to remove entirely the former without causing damage to the nerve ending. Small fragments of the core could, however, be cut out, or incisions could be made into the core tissue, without the preparation losing its characteristics as a mechanoreceptor.

In a capsule in which the peripheral zone is stripped off, myelinated or nonmyelinated parts of the axon which ordinarily lie inside the capsule can be compressed, selectively, while their mechanoresponsiveness is being tested. A fine steel hook, driven by a micromanipulator, was used for compression. If the region of the first node of Ranvier (ordinarily intracorpuscular) is compressed, the production of regenerative potentials in response to mechanical stimuli is abolished. Generator potentials can, nevertheless, still be detected. The effect is reversible if low pressures are employed.

Functioning of the nonmyelinated nerve ending is required for the production of generator potentials. After 36 hours of Wallerian degeneration of the corpuscle's afferent axon *in situ*, no generator potentials can be detected in response to mechanical stimulation. In addition, support for the foregoing statement comes from compression experiments. The nonmyelinated terminal stretch is long enough (600 μ) to be compressible, in part, or along its entire length, by a steel hook. Upon compression of the entire ending, all sign of generator potential disappears. However, production of electric activity does not require that the ending be intact. When a distal portion of the ending is compressed, this portion, only, becomes irresponsive. The intact central stump continues, nevertheless, to give generator potentials when stimulated mechanically. The effect is reversible, if low pressures are used. Furthermore, a distal portion of the corpuscle, including a fragment of capsule and nerve ending, can be amputated without immediate loss of the mechanoreceptor properties of the corpuscle's central remains. It is concluded that the regenerative potential is set up at the first intracorpuscular node of Ranvier (*5*) and that the generator potential arises at various active membrane sites distributed along the nonmyelinated nerve ending.

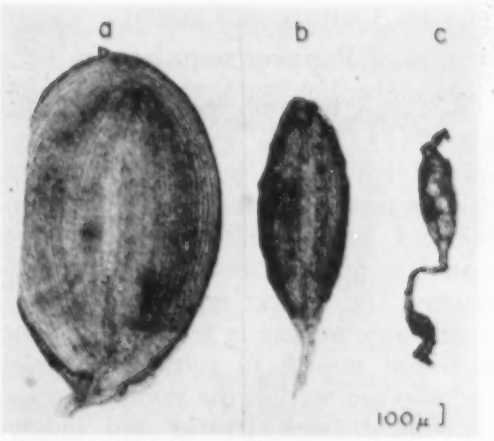


Fig. 1. Phase-contrast photomicrographs of an unstained living Pacinian corpuscle of which the capsular structure has been progressively removed. (*a*) Corpuscle before dissection; (*b*, *c*) two stages of the dissected corpuscle. Note that in *c* practically only the inner core—that is, about 1 percent of the corpuscle's entire structure—is left over, intact. The corpuscle's ability to produce impulses in response to mechanical stimuli remained unimpaired at all stages of dissection shown.

WERNER R. LOEWENSTEIN
RAQUEL RATHKAMP

Physiology Department, Columbia University, College of Physicians and Surgeons, New York, N. Y., and *Instituto de Fisiologia, Universidad de Chile, Santiago*

References and Notes

1. D. C. Pease and T. A. Quilliam, *J. Biophys. Biochem. Cytol.* 3, 331 (1957).
2. J. A. B. Gray and J. L. Malcolm, *Proc. Roy. Soc. (London)* B137, 96 (1950).
3. W. R. Loewenstein and R. Altamirano-Orrego, *Nature* 178, 1292 (1956).
4. ———, *J. Gen. Physiol.*, in press.
5. J. Diamond, J. A. B. Gray, M. Sato, *J. Physiol. (London)* 133, 54 (1956); W. R. Loewenstein, *J. Gen. Physiol.*, in press.
6. We wish to thank Dr. S. W. Kuffler for reading the manuscript. This work was aided by a grant from the Rockefeller Foundation.

14 October 1957

In vitro Culture of Excised Ovules of Papaver somniferum

Although the embryo (*1*), the endosperm (*2*), and the fruit (*3*) of angiosperms have been investigated by the culture technique, the young ovule, as far as I am aware (*4*), has not been reared to maturity under artificial conditions. The present report on *Papaver somniferum* outlines a technique for the successful growth in culture of ovules and also summarizes the results of some experiments with kinetin and indoleacetic acid on their development and maturation.

Young capsules of *Papaver* were excised from the plant and surface-sterilized by dipping in 90 percent alcohol and flaming. The capsule was then cut open, and a portion of it was fixed at once; from the remaining portion, ovules (*5*) were scooped out with a sterile scalpel and planted in Nitsch's medium (*3*) supplemented with 5 ml/lit of a mixture of vitamins (*6*). This served as the basic medium. In some cases the culture medium was supplemented with kinetin, which has recently been reported (*7*) to be extremely potent in inducing cytokinesis.

In the basic medium the ovules grew to maturity in 23 days, starting from the two-celled stage of the proembryo. In nature the time interval between pollination and maturation of ovules is shorter and usually extends to about 18 days. Ovules containing a two-celled proembryo (Fig. 1A) and free-nuclear endosperm were cultured on a medium containing kinetin (0.4 mg/lit) and indoleacetic acid (5 mg/lit). Ovules collected 9 days after planting showed globular embryos and cellular endosperm (Fig. 1B), with food reserves similar to those in naturally ripening seeds. From the same lot, 23-day-old cultures showed completely mature seeds, some of which had germinated *in situ* to produce seedlings (Fig. 1C) which were quite normal except that the radicle and root tip showed localized callusing.

A few interesting abnormalities were met with. In 9-day-old cultures some of the embryos showed lobes in which active meristems were present. Still other embryos completely lacked differentiation but showed radial rows of meristematic cells toward the margin (Fig. 1D). In one embryo the suspensor, which is normally a linear row of three or four cells, showed the appearance of a globular mass. In all these cases the endosperm was either arrested at the free-nuclear stage or had degenerated after reaching the cellular stage.

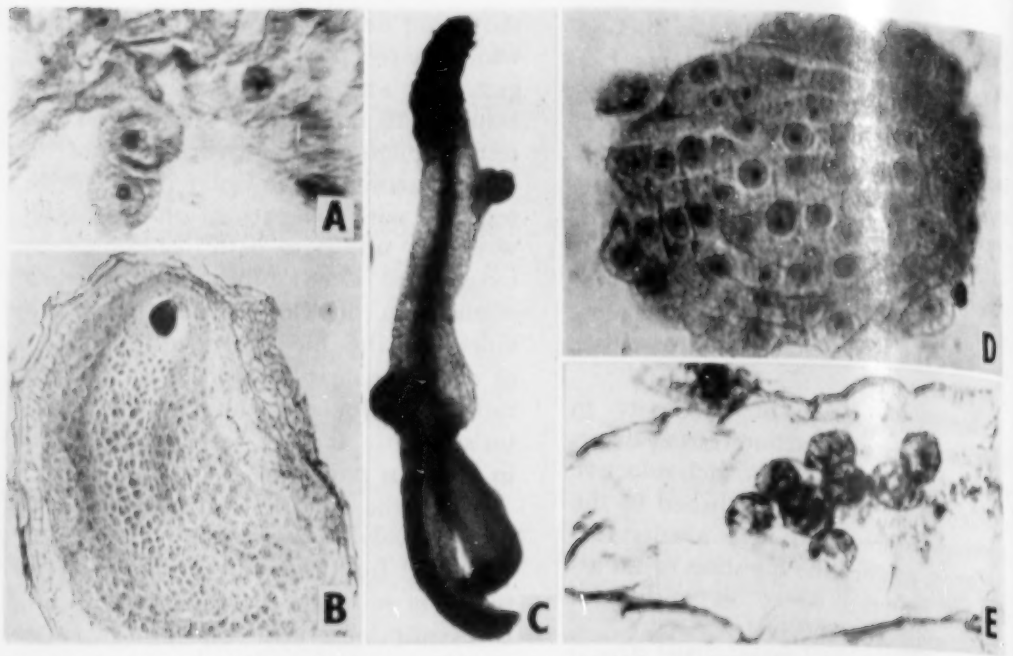


Fig. 1. Results obtained with ovules of *Papaver somniferum* cultured in Nitsch's medium supplemented with kinetin (0.4 mg/lit) plus indoleacetic acid (5 mg/lit). (*A*) Two-celled proembryo at the time of planting (×107); (*B*) globular embryo and cellular endosperm as seen 9 days after planting (×107); (*C*) seedling formed *in situ* in 23 days (×14); (*D*) 9-day-old undifferentiated embryo with radially arranged meristematic cells at the margin (×107); (*E*) eight nuclei in a single hypertrophied endosperm cell from a 9-day-old culture (×107).

In kinetin media the endosperm showed a few other changes, like renewed divisions in apparently mature cells, accumulation of as many as nine nuclei in single hypertrophied cells (Fig. 1E), and formation of patches of meristematic cells around enormously enlarged endosperm cells. Frequently mature embryos having three cotyledons or two unequal cotyledons were encountered in kinetin media. It may be noted that recently Haecius (*8*) induced twinning of cotyledons in seeds of *Eranthis hiemalis* by treatment with 2,4-dichlorophenoxyacetic acid, α-naphthalene acetic acid, and 2,4,5-trichlorophenoxyacetic acid.

The results obtained support the view of Miller *et al.* (*7*) that kinetin is a factor in cell division. The radial rows of meristematic cells seen at the periphery of late globular embryos (Fig. 1D) as well as the renewed divisions in apparently mature cells of the endosperm appear to have been induced by kinetin.

Ovule culture provides a new tool for the study of seed physiology. While emphasis has hitherto been laid on the artificial culture of excised embryos, the present study shows that entire ovules, too, are capable of being grown to maturity. In the culture of embryos it has not proved feasible to dissect out very early stages without damaging them. The culturing of ovules involves no such difficulty. Further, it may be possible, by suitable modifications of the technique and by adding various chemicals to the culture medium, to cause the formation of adventive embryos and even the induction of parthenogenesis and apogamy (*9*).

NIRMALA MAHESHWARI
Department of Botany, University of Delhi, Delhi, India

References and Notes

1. J. Rappaport, *Botan. Rev.* 20, 201 (1954).
2. E. P. Sternheimer, *Bull. Torrey Botan. Club* 81, 111 (1954).
3. J. P. Nitsch, *Am. J. Botany* 38, 566 (1951).
4. There is a very brief and preliminary report by C. L. Withner [*Am. Orchid Soc. Bull.* 11, 261 (1943)] on rearing orchid ovules in test tubes. Judging from his statement that "the older embryos seem to develop more rapidly, but there is no indication that younger ovules cannot be used as well," it appears that he took fairly old ovules for his study. C. D. La Rue [*Bull. Torrey Botan. Club* 69, 332 (1942)] and P. R. White [*Arch. Exptl. Zellforsch. Gewebezücht* 12, 602 (1932)] secured callus in cultures of snapdragon ovules. In *Erythronium americanum* it is reported that the ovules grow to 4 times their original size, but nothing further is mentioned by La Rue [*Bull. Torrey Botan. Club* 69, 332 (1942)]
5. The ovules in any one capsule of *Papaver* are more or less at the same stage of development.
6. P. R. White, *Cultivation of Animal and Plant Cells* (London, 1954).
7. C. O. Miller *et al.*, *J. Am. Chem. Soc.* 78, 1375 (1956).
8. B. Haccius, *Nature* 176, 355 (1955).
9. This work was done as part of a research project on "Chemical stimulation of ovule," financed by the Indian Council of Agricultural Research. I am indebted to Professor P. Maheshwari, under whose guidance this research was conducted. I am also grateful to Dr. R. C. Sachar for active cooperation in the work and to I. K. Vasil, Manohar Lal, and S. C. Maheshwari for helpful criticism.

16 October 1957

Book Reviews

Religion Without Revelation. Julian Huxley. Harper, New York, rev. ed. 2, 1957. 252 pp. $4.

Julian Huxley is a well-read man, as even a cursory glance at the revised edition of *Religion Without Revelation* will reveal. The mass of material paraded across the pages here is truly amazing, especially when the reader considers that Huxley is not talking about his own professional field. As a biologist he obviously has, as a person, an intense interest in religion and its history, but it is concern for religion as a human phenomenon and not as conventional Christian theology.

A comparison with the original edition indicates that Huxley has softened his attitude toward traditional religion considerably. In place of the original chapter describing the then (1927) low estate of organized religion, he has simply substituted a statement of the naturalist's approach to God. The original edition was a more militant book in a time of open revolt from traditional Christianity; this edition is simply a statement of the naturalist's sincere interest in religion.

Perhaps the most striking thing about the book as a whole, to a philosopher, is that anyone needs to argue that a nontheistic religion is possible. The Stoics had no God recognizable in our sense, and the Epicureans (notably Lucretius) long ago delivered elaborate arguments against transcendent religious beliefs. The Christian claim to revelation is not an assertion that all men must subscribe to the Christian beliefs; this would be contrary to the meaning of revelation. Revelation means that only believers accept this particular disclosure of God as being true, so that if it were not natural and possible to live without admitting the truth of the revelation, conversion would have no meaning. If religion without revelation were not always naturally attractive to some men, Christianity would lose all distinctiveness.

Huxley does give clear and well-documented support of the naturalist's view, but it will be a "new conception" (page 1) only to those people unfamiliar with philosophical history. Most of the statement, however, is a personal declaration of what he, Huxley, believes, and as such no one can argue about it. (It is helpful to remember that the book was originally published as one of a series on "What I Believe.")

His call for the application of scientific method to religion (page 4) seems not to have taken hold, and today what we find more prevalent is an attempt to establish theological methods upon their own foundations. Not that science is being ignored; the truth is that modern science has been completely accepted, but it has not seemed able to serve as a basis for theological revival. The challenge of science seems to have had the effect of driving theology in search of its own methodology rather than of reforming it as a branch of the natural sciences.

Huxley's modern reinterpretation of traditional doctrines (for example, the trinity treated as nonhuman forces, ideals, and human nature) is one possible account of what has often been described in different ways, but it surely does not of itself prove that traditional doctrines can no longer be interpreted traditionally by thoughtful persons. God, as Huxley indicates, may not be a useful hypothesis, as a trinity or otherwise, to science; but this does not say that God may not remain a hypothesis in nonscientific disciplines. Huxley's reinterpretation is surely possible; the only question arises from his apparent assumption that a new interpretation makes traditional views no longer tenable. After all, theology may not be as scientific as all that.

FREDERICK SONTAG
Pomona College

The Carbohydrates. Chemistry, biochemistry, physiology. Ward Pigman, Ed. Academic Press, New York, 1957. xvii + 902 pp. $20.

This is a complete revision and expansion of *The Chemistry of the Carbohydrates* by W. Pigman and R. M. Goepp, Jr., published in 1948, although, according to the editor, considerable borderline material has been deleted and a number of chapters have been condensed. The present volume contains sections on the structure, stereochemistry, occurrence, properties, and synthesis of the monosaccharides; the chemistry of carbohydrate esters; chemistry of the glycosides, simple acetals, and thioacetals; chemistry of the polyols; carbohydrate acids and acid products; carbohydrate esters and hydrosugars and unsaturated derivatives; carbohydrate nitrogenous derivatives; oligosaccharides; naturally occurring glycosides and glycosidases; and chemistry of polysaccharides, as well as a section on methods for the quantitative determination of carbohydrates. All of these topics are treated in ample detail, with copious references to the appropriate literature, principally from the standpoint of the organic chemist. These chapters would serve admirably as a reference work for interested individuals and as a text for the advanced student of chemistry.

The volume also contains two new chapters, one dealing with photosynthesis and carbohydrate metabolism and the other with carbohydrates and nutrition. These are adequate in terms of a very rapid survey. However, only eighty-odd pages of a total of 902 are devoted to these aspects of the carbohydrates, and they hardly justify the use of the terms *biochemistry* and *physiology* as part of the title of the volume.

EARL A. EVANS, JR.
University of Chicago

Morphological Astronomy. F. Zwicky. Springer, Berlin, 1957. iv + 299 pp. Illus. DM. 49.60.

This book, by a well-known astronomer of Mount Wilson and Palomar Observatories, is an unusual mixture of factual information on one of the most important of astronomical subjects—galaxies—and a development of the author's ideas on the morphological method. These latter he bases on Faraday's concept "that ultimately all things are interrelated in a most surprising variety of ways."

In his morphological approach to science, the author takes a strong stand against the present trend of research to learn more and more about less and less. "The morphological method always attempts to attain the most general perspective." The main emphasis in the book is definitely on galaxies—a field in which the author uses his own researches to illustrate the morphological approach. On galaxies, there is a vast amount of material of value to both the professional astronomer and to the student, including some excellent photographs. We cannot help regretting, however, that Zwicky keeps all distances of galaxies on

the old scale, acknowledged to be in great error, without adopting an approximate correction to a new scale. The author deals with such perennially thorny topics as the distribution of galaxies, the presence of intergalactic matter, and the luminosity function for galaxies. A subtitle might well be "Colliding theories of galaxies."

In addition to galaxies, the author discusses a wide variety of topics. As an illustration of the morphological approach he outlines a standardized system by which scientists can dispose of "Bothersome Inquiries." In view of the schedule-disrupting impact of sputniks I and II on the lives of many astronomers, this section is of particularly pertinent and timely interest. Although the morphological approach demands an "unprejudiced interest in all things" (page 283), the reader may wonder, from the author's decided opinions on various topics—for example, from his comments on the program for the 48-inch Schmidt telescope at Palomar (page 39) and his sweeping disparagement of observational astronomy in seven well-known countries (page 5)—whether Zwicky himself has been able to avoid prejudices.

Certainly anyone interested in galaxies should familiarize himself with the material in this book. In so doing he will doubtless become interested in pursuing his own lines of reasoning in the light of the morphological approach outlined by Zwicky.

HELEN SAWYER HOGG
University of Toronto

Recent Progress in Hormone Research. vol. XIII. *Proceedings of the Laurentian Hormone Conference 1956.* Gregory Pincus, Ed. Academic Press, New York, 1957. viii + 646 pp. Illus. $12.80.

This book follows in the tradition of previous volumes of this series in providing lucid and provocative accounts of endocrinologic subjects of timely interest. An especially valuable feature of the book, as of the earlier volumes, consists of a complete coverage of the often spirited discussions following the formal presentations of the papers by recognized authorities in endocrinology.

The present volume is divided into five sections. Section I deals with "Neurohumoral-Endocrine Relationships." The first paper, by Udenfriend, Shore, Bogdanski, Weissbach, and Brodie, gives a cogent account of the "Biochemical, physiological and pharmacological aspects of serotonin." E. Anderson, Bates, Hawthorne, Haymaker, Knowlton, M. Rioch, Spencer, and H. Wilson report new experiments on "The effects of midbrain and spinal cord transection on endocrine and metabolic functions with postulation of a midbrain hypothalamico-pituitary activating system." A succinct analysis of hypothalamic-hypophyseal interrelations is presented in the paper on "Studies on the influence of the central nervous system on anterior pituitary function," by Greer. C. P. Richter, in his paper on "Hormones and rhythms in man and animals," describes an interesting correlation of cycles of behavior and metabolism in psychiatric patients and the production of similar cycles in rats through interference with thyroid, pituitary, and brain function.

Section II deals with "Hormone Transport in Circulation." Recent concepts of the binding of thyroid hormone and of steroids to proteins in body fluids are provided in excellent studies on "The interaction of thyroid hormones and protein in biological fluids," by Robbins and Rall, and on "The binding of steroids and steroid conjugates to human plasma," by Sandberg, Slaunwhite, and Antoniades.

The assignment of section III to "Aspects of Reproduction" no doubt stems from the recent active interest in the effects of the newly synthesized steroidal derivatives on reproductive processes in man. A fundamental background to the problem is provided in the paper by Schlesnyak on "Some experimental studies on the mechanism of ova-implantation in the rat," which includes some interesting new data on the effects of histamine, epinephrine, and ergotoxine on decidual cell development and nidation. Following this are two clinical papers, one dealing with "Synthetic progestins in the normal menstrual cycle," by Rock, Garcia, and Pincus, and the second with "The metabolism of progesterone and its clinical use in pregnancy," by Davis and Plotz. A discussion of the use of progestational steroids in inhibiting ovulation and in the treatment of infertility and habitual abortion in women is included in these papers. A note of caution is voiced in Carl Hartman's remarks (page 345) on the possible toxic effects with prolonged use of these agents. This section is concluded with an instructive paper by Junkmann on "Long-acting steroids in reproduction," dealing with the influence of esterified androgens, estrogens, and progestogens on reproductive organs and processes in rodents.

Section IV is devoted to "Hormone Chemistry and Metabolism." Mirsky gives a clear description of his more recent work in "Insulinase, insulinase-inhibitors and diabetes mellitus." Evidence is presented that a variety of compounds of the plant growth hormone structure are insulinase inhibitors and display hypoglycemic actions in animals. The question is raised in the ensuing discussion whether some forms of diabetes mellitus might not have a nonendocrine origin. The second paper in this section is concerned with a survey of the chemical properties and actions of "Glucagon, a second pancreatic hormone," by Foa, Galansino, and Pozza. Some parts of the discussion that follows this paper debate the validity of including glucagon as a legitimate member of the endocrine system.

Section V includes two comprehensive papers on problems relating to "Hormones and Stress." The first, by Moore, on "Endocrine changes after anesthesia, surgery and unanesthetized trauma in man," reports the adrenal cortical response to traumatic experiences in man and the possible teleological significance of these adrenal alterations. The second paper, by Gray and Ramsey, on "Adrenal influences upon the stomach and gastric responses to stress," reviews the evidence for an adrenal-gastric relation in animals and man and concludes with a consideration of the relation of the adrenal and stress to the production of gastric ulcers.

The program organizing committee of the Laurentian Hormone Conference, the participants, and the publishers deserve praise for their efforts in making the present volume one of the best in this valuable series.

ALBERT S. GORDON
New York University

The American Economy. Alvin H. Hansen. McGraw-Hill, New York, 1957. xv + 199 pp. $5.

The essential part of this short book originated in six lectures sponsored by the Charles R. Walgreen Foundation at the University of Chicago during 1956. The lectures are concerned broadly with the role of government in the growth and progress of the U.S. economy. Hansen gives his interpretation of the recent course of economic events in the United States and Western Europe. He devotes much attention to the purposes of the Employment Act of 1946 and the way in which it was implemented by both the Truman and the Eisenhower administrations. He treats of monetary policy and of standards and values in a rich society. The book ends with an essay on Keynesian economic thinking and has an appendix on Woodrow Wilson as an economic reformer.

Hansen argues that economic stagnation followed World War I, while expansion and growth followed World War II, and that this was due to a transition from "low pressure economics" to

"high pressure economics." Although these phrases—coined by Wallich—are not precisely defined by Hansen, they seem to be euphemisms for "noninflationary" and "inflationary" policies. Hansen prefers the second type of economic policy. He summarily dismisses the remarkable revival of West Germany under "low pressure" (noninflationary) policies—a fact not convenient to his thesis—as being due to extensive state enterprise, to a large governmental budget, and to inflationary policies in other countries which created export markets for German goods. However, Hansen has the facts wrong. On the basis of the percentages of total product produced in the public and in the private sectors, next to the United States, West Germany has the most individualistic economy of the Western nations.

If "high pressure" economic measures are continuously taken by government, inflation of the price level must inevitably result. However, Hansen assures us we need fear only "pure inflation," which he defines as a situation in which the price level rises without any appreciable increase in output. So long as the percentage increase in output exceeds the percentage rise in the price level, all is well. "It is not probable that we can achieve in the next twenty years anything like the growth of which we are capable, without some moderate increases in wholesale and consumer prices," writes Hansen (page 45). However, he does not advocate a monetary policy to produce price inflation, and he expresses the hope that full economic growth can be achieved with stable prices (page 49). There is a curious inconsistency here. If price inflation is, indeed, necessary to call forth maximum output, then why should one "hope" that price inflation can be avoided?

This whole line of reasoning ignores (as I have pointed out elsewhere) the fact that continual price level increases over a long enough time generate public expectations which alter public behavior in ways that curtail real output and accelerate the rate of price increase. In other words, an inflationary policy must in the end *reduce* real output under its full potential. However, maximum growth of real output is consistent with a stable price level only when there is adequate mobility of economic resources and adequate two-way flexibility of individual prices. The attack on the inflation problem must rely not only upon monetary and fiscal measures but also upon antimonopoly, tax, international trade, and other policies to increase resource mobility and price flexibility.

NEIL H. JACOBY
Graduate School of Business Administration, University of California, Los Angeles

New Books

National Science Foundation, Seventh Annual Report for the Fiscal Year Ended June 30, 1957. National Science Foundation, Washington, D.C., 1958 (order from Supt. of Documents, GPO, Washington 25). 279 pp. $1.

Atoms, Energy and Machines, Jack McCormick, 224 pp.; *The Earth's Story,* Gerald Ames and Rose Wyler, 222 pp.; *Planets, Stars, and Space,* Joseph Miles Chamberlain and Thomas D. Nicholson, 223 pp.; *The Way of the Weather,* Jerome Spar, 224 pp. Published in cooperation with American Museum of Natural History, New York, by Creative Educational Society, Manakato, Wis., 1957.

System Engineering. An introduction to the design of large-scale systems. Harry H. Goode and Robert E. Machol. McGraw-Hill, New York, 1957. 563 pp. $10.

Mineral Nutrition and the Balance of Life. Frank A. Gilbert. University of Oklahoma Press, Norman, 1957. 365 pp. $5.95.

Emulsions: Theory and Practice. Paul Becher. Reinhold, New York; Chapman & Hall, London, 1957. 391 pp. $12.50.

Thermodynamics of Heat-Power Systems. F. W. Hutchinson. Addison-Wesley, Reading, Mass., 1957. 501 pp. $8.50.

Portrait of an American Labor Leader: William L. Hutcheson. Saga of the United Brotherhood of Carpenters and Joiners of America, 1881–1954. Maxwell C. Raddock. American Institute of Social Science, New York, 1955. 448 pp. $5.

The Treatment of Trade-Waste Waters and the Prevention of River Pollution. Proceedings of a course held in the Department of Civil Engineering, King's College, Newcastle upon Tyne, 1–12 Apr. 1957. Peter C. G. Isaac, Ed. Public Health Engineering Section, University of Durham, King's College, in association with Contractors' Record Ltd., London, England, 1957. 326 pp. 45s.

Principles of Physical Chemistry. An introduction to their use in the biological sciences. Wallace S. Brey, Jr. Appleton-Century-Crofts, New York, 1957. 441 pp. $7.

The Chemical Dynamics of Bone Mineral. William F. Neuman and Margaret W. Neuman. University of Chicago Press, Chicago, 1958. 220 pp. $5.

The World Beneath the Waves. Gilbert Doukan. Translated by A. and R. M. Case. De Graff, New York, 1957. 356 pp. $6.

Puzzle-Math. George Gamow and Marvin Stern. Viking, New York, 1958. 119 pp. $2.50.

Differential Equations: Geometric Theory. Solomon Lefschetz. Interscience, New York, 1957. 374 pp. $9.50.

Integral Equations. F. G. Tricomi. Interscience, New York, 1957. 246 pp. $7.

Adventures in Medical Education. A personal narrative of the great advances of American medicine. G. Canby Robinson. Harvard University Press (for Commonwealth Fund), Cambridge, 1957. 350 pp. $5.

The Mango. S. R. Gangolly, Ranjit Singh, S. L. Katyal, and Daljit Singh. Indian Council of Agricultural Research, New Delhi, 1957. 543 pp. $12.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

The Lynn Index. A bibliography of phytochemistry. Monograph I, *Order, Centrospermae.* Organized and edited by John W. Schermerhorn and Maynard W. Quimby. Massachusetts College of Pharmacy, Boston, 1957. 46 pp.

Hanunóo Agriculture. A report on an integral system of shifting cultivation in the Philippines. FAO Forestry Development Paper No. 12. Harold C. Conklin. Food and Agriculture Organization of the United Nations, Rome, 1957. 209 pp. $2.

Rubber and Resin Content. William H. Minshall. Canada Department of Agriculture, Ottawa, Ontario, 1957 (available from the Author, Science Service Laboratory, University Sub Post Office, London, Ontario, Canada). 53 pp.

The Sarawak Museum Journal. vol. VII, No. 9. An annotated checklist of the birds of Borneo. B. E. Smythies. The Museum, Kuching, Sarawak, 1957. 308 pp. $3.

Booklet on Sanitation History. Centenary of the graduation of Dr. Carlos J. Finlay in Jefferson Medical College. Cesar Rodriguez. Ministry of Health and Social Assistance, Havana, Cuba, 1956. 74 pp.

The Structure and Reproduction of Some Members of the Rhodymeniaceae. Publs. in Botany, vol. 29, No. 3. Shirley Ray Sparling. 78 pp. $1.50. *A Synopsis of Hymenopterous Parasites of Malacosoma in California (Lepidoptera, Lasiocampidae).* Publs. in Entomology, vol. 14, No. 1. Robert L. Langston. 50 pp. $1. *The Distribution of Radioisotopes of Some Heavy Metals in the Rat.* Publs. in Pharmacology, vol. 3, No. 1. Patricia W. Durbin, Kenneth G. Scott, Joseph G. Hamilton. 34 pp. $0.75. *Development of Hymenolepis Nana and Hymenolepis Diminuta (Cestoda: Hymenolepididae) in the Intermediate Host Tribolium Confusum.* Publs. in Zoology, vol. 59, No. 9. Marietta Voge and Donald Heyneman. 32 pp. $0.75. University of California Press, Berkeley, 1957.

Shall I Study Geological Sciences? American Geological Institute, 2101 Constitution Ave., NW, Washington, D.C. 16 pp. Free; five or more copies, $0.10 each.

Directory of Geological Material in North America. J. V. Howell and A. I. Levorsen. Revised by Robert H. Dott and Jane Weaver Wilds. American Geological Institute, Washington, ed. 2, 1957. 208 pp. $3.

Commonwealth Scientific and Industrial Research Organization, Australia, Ninth Annual Report. For the year ending 30 June 1957. Commonwealth of Australia, Melbourne, C.2, 1957. 36 sections.

The Development of a Mobile Acoustics Laboratory. WADC Rept. 56–656. Lothar O. Hoeft. 25 pp. *Metrical Relations among Dimensions of the Head and Face.* WADC Tech. Rept. 56–621. Edmund Churchill and Bruce Truett. 127 pp. Wright Air Development Center, Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, 1957 (order from ASTIA Document Service, Knott Building, Dayton 2, Ohio).

Meetings and Societies

Origin of Life

An international symposium on the Origin of Life on Earth was held in Moscow, U.S.S.R., 19–24 August 1957. The symposium was organized by the Academy of Sciences of the U.S.S.R. under the auspices of the International Union of Biochemistry. The general chairman of the conference was A. I. Oparin, author of the book *The Origin of Life on Earth,* which appeared recently in its third edition. A full publication comprising the papers and discussion at the symposium is in preparation.

The group from the United States was the largest of those from any of the 17 foreign countries represented, the total being over 40 scientists from outside the U.S.S.R. The American participants were Melvin Calvin, Erwin Chargaff, Sidney W. Fox, Heinz Fraenkel-Conrat, Norman H. Horowitz, Stanley L. Miller, Alfred E. Mirsky, Linus Pauling, Stanley Scher, and Wendell M. Stanley; Christopher Reid was present from Canada. Stanley and Fox were delegates from the National Committee of Biochemistry of the United States. Calvin presided at the closing session, at which it was resolved to request the International Union of Biochemistry to hold this subject on its agenda for future symposia.

In the first session, various ideas concerning the primitive atmosphere, hydrosphere, and lithosphere were discussed. Much of this bore on the origin of petroleum as well as on the origin of life, and the notion of an abiogenic origin of petroleum received renewed attention. V. A. Sokolov attempted to trace the earth through its stages of formation, warming, cooling, and biogenesis. J. D. Bernal gave a particularly lucid analysis of the component problems in the study of life's origin. During the discussion, Horowitz developed the point of view that the genes are the only living parts of the cell, everything else being products of genic activity. A. E. Braunstein argued, however, that only the entire cellular system shows the properties of life.

In the second session, Miller presented recent data on his well-known experiments on the formation of amino acids from assumedly primitive gases. He reported that carbon monoxide may be substituted for methane, and ultraviolet radiation for electrical discharge. Carbon monoxide as a component of experimental mixtures of gases insures reducing conditions. Experiments of this sort have been extended in A. G. Passynsky's laboratory. Braunstein discussed ways in which some of the more complex amino acids may have arisen. Berg, a geochemist, explained how life might have begun in the earth or at the bottom of a shallow pool, either locale serving to protect the first life from destructive radiation.

In the session on the origin of proteins, nucleoproteins, and enzymes, S. Akabori discussed how a polyglycine might have arisen and been gradually supplanted by side chains. Experiments with polyglycine on kaolinite, to yield serine, threonine, and leucine or isoleucine residues, were described. Calvin's talk on chemical evolution stressed the similarities of reactions of biological and of organic chemistry. Pauling discussed duplication of molecules in organisms. R. L. M. Synge pointed out that the amino acids in the biochemistry texts are essentially the same as those described 30 years ago. Fox reported thermal experiments producing amino acids and peptides from the critical dicarboxylic amino acids and yielding the nucleic acid intermediate, ureidosuccinic acid. These reactions are linked; a benthic locale and a chemical memory mechanism were proposed. M. G. Kritzman reported on enzymic behavior in simple proteins.

In the next session, Chargaff reported that all deoxyribonucleic acid preparations examined consist of trains of polypyrimidines and polypurines in groups of three, and that the arrangements are far from random. Fraenkel-Conrat raised the question of whether virus research should be represented at the symposium and reported on his work. In his studies of recombination of nucleic acid and protein preparations, the nucleic acid is now recognized to be totally dominant. G. Schramm emphasized the importance of polyphosphate in natural polymerization and therefore probably in prebiological chemistry. Stanley spoke on the nature of viruses, genes, and life, with special emphasis on relationships between viruses and genes as represented especially by the transduction phenomenon. He also stressed the central place of the viruses in providing a transition from molecules to organisms. Mirsky reported on his recent experiments in which small polynucleotides can substitute for nucleic acids and serve as cofactors for synthesis of adenosine triphosphate. The discussion at the end of this day concerned such problems as defining life and deciding whether viruses are alive. In summary, Oparin asked if life is merely nucleic acid and protein or these plus the rest of the cell.

In the session on origin of structure and metabolism, Oparin discussed work with coacervates. F. B. Straub expressed his view that a single precursor may serve in the production of separate enzymes—an inference which has support from other recent work. G. A. Deborin emphasized that proteins do not occur singly.

In a first session on evolution of metabolism, Braunstein and W. L. Kretovich presented reasons for believing that aspartic acid is more primitive than glutamic acid. Braunstein and M. Ishimoto each cited P. W. Wilson for evidence that ammonia is an intermediate in nitrogen fixation.

In the next session, Reid discussed the production of amino acids and the fact that irradiation of cystine yielded six or seven amino acids. D. I. Sapozhnikov discussed the evolution of phototrophy. Scher amplified Copeland's proposal, supported by his own nutritional data, that life began in thermal waters. The discussion at this, the closing session, centered on the concept of thermal origins. Bernal commented that early short-chain proteins may have been more thermostable than contemporary proteins. A concept of the recapitulation of prebiotic pathways by biotic pathways, as proposed by Fox's thermal theory, was criticized by some of the discussants, supported by others. Oparin closed the discussion on the note that the divergences of opinion expressed in the symposium cannot be settled by vote or debate—a statement which repeated what Pauling had said earlier.

The arrangements for the symposium followed the pattern of similar international conferences held in Russia within the last 2 years. Invited foreign participants were provided, upon arrival, with a sum of rubles calculated on the basis of 100 per day. Hotel bills, banquets, and railroad tickets were gratis. Various visitors spent money on records, books, telephone calls to home (48 rubles or $12 official rate, $4.80 unofficial rate, to the United States), caviar, tickets to the

ballet, the puppet show, art centers, and so on.

The scientific program was printed in both Russian and English. Translation through headphones was provided by a corps of translators who translated English into Russian, Russian into English, and German or French into Russian. The quality of some of these translations was inferior to the superb service at the United Nations sessions, for example, and was such as to hamper discussion seriously in some cases. Guides were available for official tours, and were optional for informal sightseeing.

Institutes visited in Moscow included the Bakh Institute of Biochemistry (A. I. Oparin, director), the Microbiology Institute, the Vernadsky Institute of Analytical and Geochemistry, and the Institute of Genetics (T. Lysenko, director). In Leningrad, the institutes visited included the Pavlov Institute, the very well equipped Macromolecular Institute, and the Botanical Institute. Other visits included art museums, the Lenin-Stalin mausoleum, the Kremlin, and the State University of Moscow.

Because of the interdisciplinary nature of biochemistry, it was possible to form comparative opinions about fields of science in Russia. Physics appears to be most favored, chemistry next, and biology least. Biology, in the opinion of Americans, also suffers from belated recognition of the value of modern developments in genetics. The chair of genetics at the University of Moscow was vacant, for example. Remarks based on Beadle's concepts of gene-reaction relationships were of diminished significance to Russian observers interested in the origin of life.

The visitors found that the scientists and others, even on the street, were very eager to communicate with visitors and were friendly. The hosts were extremely hospitable.

SIDNEY W. FOX
Oceanographic Institute, Florida State University, Tallahassee

Forthcoming Events

March

9–14. International College of Surgeons, 11th biennial cong., Los Angeles, Calif. (K. A. Meyer, 1516 Lake Shore Dr., Chicago 10, Ill.)

10–13. American Assoc. of Petroleum Geologists, annual, Los Angeles, Calif. (R. H. Dott, AAPG, Box 979, Tulsa 1, Okla.)

10–13. Society of Economic Paleontologists and Mineralogists, annual, Los Angeles, Calif. (R. H. Dott, Box 979, Tulsa, Okla.)

16–21. Nuclear Engineering and Science Cong., Chicago, Ill. (D. I. Cooper, *Nucleonics*, 330 W. 42 St., New York.)

17–21. National Assoc. of Corrosion Engineers, 14th annual, San Francisco, Calif. (NACE, Southern Standard Bldg., Houston 2, Tex.)

18–20. Amino Acids and Peptides, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

19. Clinical Uses of Nuclear Reactors, symp., Cambridge, Mass. (C. J. Maletskos, Medical Dept., Massachusetts Inst. of Technology, Cambridge 39.)

20–22. Michigan Acad. of Science, Arts and Letters, annual, Ann Arbor. (R. F. Haugh, Dept. of English, Univ. of Michigan, Ann Arbor.)

20–22. Pulmonary Circulation Conf., Chicago, Ill. (Wright Adams, Chicago Heart Assoc., 69 W. Washington St., Chicago 2.)

20–23. International Assoc. for Dental Research, annual, Detroit, Mich. (D. Y. Burrill, Northwestern Univ. Dental School, 311 E. Chicago Ave., Chicago 11, Ill.

23–26. American Assoc. of Dental Schools, annual, Detroit, Mich. (M. W. McCrea, 42 S. Greene St., Baltimore 1, Md.)

23–29. American Soc. of Photogrammetry, 24th annual, jointly with American Cong. on Surveying and Mapping, 18th annual, Washington, D.C. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5.)

24–26. Aero Medical Assoc., 29th annual, Washington, D.C. (T. H. Sutherland, Box 26, Marion, Ohio.)

24–27. Institute of Radio Engineers, natl. conv., New York. (G. W. Bailey, IRE, 1 E. 79 St., New York 21.)

26–28. American Power Conf., 20th annual, Chicago, Ill. (Illinois Inst. of Technology, 35 W. 33 St., Chicago 16.)

27–29. American Physical Soc., Chicago, Ill. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

27–29. Mechanisms of Hypersensitivity, 8th internatl. symp., Detroit, Mich. (W. J. Nungester, Dept. of Bacteriology, Univ. of Michigan, Ann Arbor.)

27–29. National Science Teachers Assoc., 6th natl., Denver, Colo. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

27–29. Optical Soc. of America, annual, Washington, D.C. (S. S. Ballard, Scripps Institution of Oceanography, San Diego 52, Calif.)

28. New Jersey Acad. of Science, 3rd annual, Newark. (H. L. Silverman, Nutley Public Schools, Nutley, N.J.)

29. South Carolina Acad. of Science, annual, Charleston. (Miss M. Hess, Dept. of Biology, Winthrop College, Clemson, S.C.)

29–30. American Psychosomatic Soc., 15th annual, Cincinnati, Ohio. (T. Lidz, 551 Madison Ave., New York 22.)

30–3. American College Personnel Assoc., annual, St. Louis, Mo. (L. Riggs, DePauw Univ., Greencastle, Ind.)

April

1. Microcirculatory Conf., 5th, Buffalo, N.Y. (S. R. M. Reynolds, Dept. of Anatomy, Univ. of Illinois College of Medicine, 1853 W. Polk St., Chicago 12.)

1–3. Corrosion Control, 5th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

2–4. American Assoc. of Anatomists, annual, Buffalo, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

2–4. Instruments and Regulators Conf., Newark, Del. (W. E. Vannah, Control Engineering, 330 W. 42 St., New York 36.)

3–5. Pennsylvania Acad. of Science, annual, Easton, Pa. (G. R. Stevens, Dept. of Geology and Geography, Lafayette College, Easton.)

4–5. Southern Soc. for Philosophy and Psychology, annual, Nashville, Tenn. (W. B. Webb, U.S. Naval School of Aviation Medicine, Pensacola, Fla.)

7–11. American Assoc. of Cereal Chemists, annual, Cincinnati, Ohio. (J. W. Pence, Western Utilization Research Laboratories, Albany, Calif.)

8–10. Electronic Waveguides Symp., New York. (J. Fox, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

9–12. National Council of Teachers of Mathematics, Cleveland, Ohio. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

9–14. Applied Psychology, 13th internatl. cong., Rome, Italy. (L. Meschieri, National Inst. of Psychology, Rome.)

10–11. American Inst. of Chemists, annual, Los Angeles, Calif. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

10–12. Biometric Soc., ENAR, Gatlinburg, Tenn. (T. W. Horner, General Mills, Inc., 400 Second Ave. South, Minneapolis 1, Minn.)

10–12. National Speleological Soc., annual, Gatlinburg, Tenn. (G. W. Moore, Geology Dept., Yale Univ., New Haven, Conn.)

10–12. Ohio Acad. of Science, annual, Akron, Ohio. (G. W. Burns, Dept. of Botany, Ohio Wesleyan Univ., Delaware.)

11. Vitamin B-12 Symp., New York, N.Y. (Miss J. Watson, 451 Clarkson Ave., Brooklyn 3, N.Y.)

11–12. Eastern Psychological Assoc., annual, Philadelphia, Pa. (G. Lane, Dept. of Psychology, University of Delaware, Newark.)

11–18. Horticultural Cong., 15th internatl., Nice, France. (Secretariat General, 84, rue de Grenelle, Paris 7e, France.)

12. Society for the Scientific Study of Religion, New York. (L. Whitman, 297 Fourth Ave., New York, N.Y.)

13–14. American Soc. for Artificial Internal Organs, Philadelphia, Pa. (G. Schreiner, Georgetown Univ. Hospital, Washington 7.)

13–18. American Chemical Soc., 133rd, San Francisco, Calif. (R. M. Warren, ACS, 1155 16 St., NW, Washington 6.)

13–19. Federation of American Societies for Experimental Biology, annual, Philadelphia, Pa. (M. O. Lee, FASEB, 9650 Wisconsin Ave., Bethesda 14, Md.)

14–16. Automatic Techniques Conf., Detroit, Mich. (J. E. Eiselein, RCA, Bldg. 10–7, Camden 2, N.J.)

(See issue of 24 January for comprehensive list)

LEISS

Single and Double
MIRROR-MONOCHROMATORS

with exchangeable prisms for the visible, ultraviolet, infrared from 200 millimicrons to 20 microns

Write for Bulletin #980 to

PHOTOVOLT CORP.
95 Madison Ave. New York 16, N.Y.

A new approach to the problem of alcoholism

THE HANGOVER

By
BENJAMIN KARPMAN, M.D.
Chief Psychotherapist
St. Elizabeths Hospital
Washington, D.C.

A **frank** and **penetrating** study in which the "hangover" is shown to be symptomatic of the specific underlying personality disorders leading to alcoholism. Summaries of these case histories are incorporated in the interpretations. REFLECTED IN THE HANGOVER ARE VIRTUALLY ALL PSYCHOLOGICAL ASPECTS OF ALCOHOLISM.

From the Reviews:

"Dr. Karpman, **in terse and often moving language,** lifts the curtain on 'slices' in the lives of fourteen alcoholics (seven men and women), showing how their hangovers reflect their emotions and 'especially the ever-present, ever-recurring problem of guilt' "—*Newsweek*

"The orientation is psychoanalytic and the presentation so authoritative that this book will undoubtedly take its place as a **basic source book** on the subject."—*Journal of Clinical Psychology.*

". . . the author has added considerably to the understanding of the psychodynamics of alcoholism."—*Digest of Neurology and Psychiatry*

560 pages (6 x 9) 16 illustrations
Published 1957 Sent on approval, $9.50

CHARLES C THOMAS • PUBLISHER
301-327 East Lawrence Avenue • Springfield, Illinois

WINTHROP'S 1958 PRICE LIST

ON BULK CHEMICALS IS NOW READY!

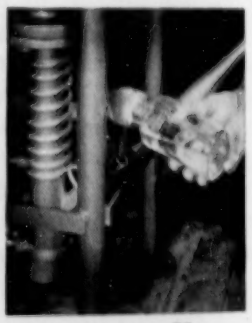
If you want a copy, fill out coupon below.

Winthrop LABORATORIES

SPECIAL CHEMICALS DEPT. S-28
1450 BROADWAY, N.Y. 18

Name .....
Firm .....
Street Address .....
City ..... Zone ..... State .....

DIFFUSION PUMP OIL
COSTS CUT IN HALF



If you operate a vacuum system at pressures below a micron, chances are that Narcoil-40® can halve your diffusion pump oil costs and give better performance, too! That's because multi-purpose Narcoil-40 combines the best features of special purpose diffusion pump oils costing several times as much. It gives you high forepressure tolerance, untrapped blank-offs to 2×10^{-7} mm Hg., plus high oxidation resistance and chemical stability. Jets stay clean for months. Pints $7.75; Quarts $14.50; Gallons $38.50; 55 gallon drums $24.50 per gallon.

Sound too good to be true? Order some today, and if you're not completely satisfied, we'll refund your money PLUS $5.00 for your trouble. For more information on Narcoil-40 or Narcoil-10, its companion oil for booster diffusion pumps, write today.

NRC
EQUIPMENT CORPORATION

DEPT. 25P, 160 CHARLEMONT ST., NEWTON 61, MASS.
A Subsidiary of National Research Corp.

LETTERS

The editors take no responsibility for the content of the letters published in this section. Anonymous letters will not be considered. Letters intended for publication should be typewritten double-spaced and submitted in duplicate. A letter writer should indicate clearly whether or not his letter is submitted for publication. For additional information, see Science **124,** *249 (1956) and 125, 16 (4 Jan. 1957).*

Image of the Scientist

The article by Margaret Mead and Rhoda Métraux, "The Image of the Scientist among High-School Students" [*Science* 126, 384 (1957)], should not, I feel, go unchallenged. While I am extremely dubious about the wisdom of certain of their recommendations, I will confine my comments to the relevance of the conclusions to the data.

Their major conclusion is summed up in the following quotation: "In general, the study shows that, while an official image of the scientist—that is, an image that is the correct answer to give when the student is asked to speak without personal career involvement—has been built up which is very positive, that is not so when the student's personal choices are involved. Science in general is represented as a good thing. . . . However, when the question becomes one of personal contact with science, as a career choice or one involving the choice of a husband, the image is overwhelmingly negative."

How is this conclusion established? Great emphasis is placed on the fact that forms II and III of those cited in the article ask a question in personal terms, whereas form I asks a question in impersonal terms. No evidence is presented, however, to show that the difference in responses to the forms is a function of the personal element. The fact is, form I is deliberately phrased with neutral emotional content, form II calls for a listing of sympathetic responses, and form III evokes antipathetic responses. This circumstance alone might be sufficient to account for the differences in the responses.

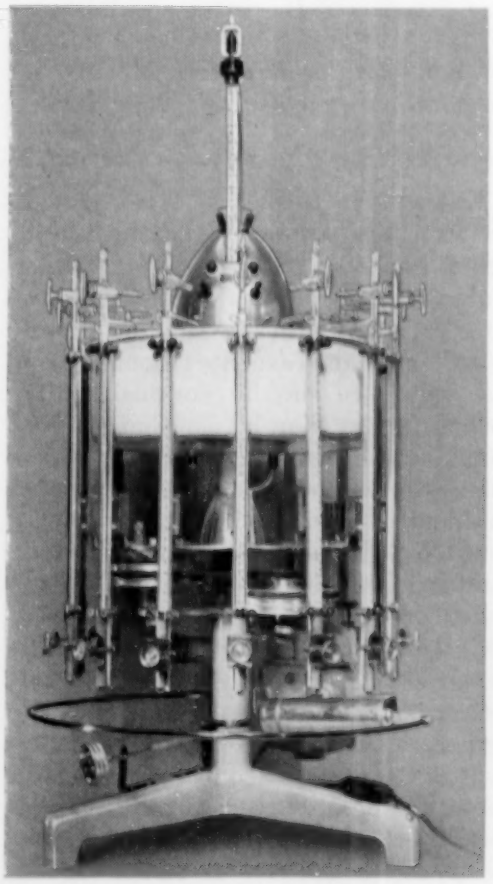
As a matter of fact, the statement is made, "The 'official' image of the scientist . . . which was evoked primarily in form I, but which recurs in the answers to *all three forms,* is a positive one" (italics mine). The basis for the conclusion that "the image is overwhelmingly negative" comes from unauthenticated data originating wholly outside the scope of the investigation. The key paragraph is: "But this image . . . is one which is likely to invoke a negative attitude as far as personal career or marriage choice is concerned. While the rejection of the negative image is, of course, immediately clear, the positive image of very hard, only occasionally rewarding, very responsible work is also one which, while it is respected, has very little attraction for young Americans today. They do not wish to commit themselves to long-time perspectives, to dedication, to single absorbing purposes, to an abnormal relationship to money, or to the risks of great responsibility. These requirements are seen as far too exacting."

Appended to the foregoing passage is the following remarkable footnote: "In this statement, we draw not only on the attitudes in this study but on a wide variety of other materials on the attitudes of contemporary young Americans." No references, no citations of authorities or of previous studies, just a flat statement that contemporary youth is unsympathetic to its image of the scientist. Even if this assertion be accepted as true, why the condescension toward contemporary American youth? In how many societies, in how many ages, would a broad cross section of the population (let alone youth) display devotion to long-term perspectives and single absorbing purposes?

This study, however, fails to establish

THE "BRONWILL"* Warburg

most compact-most versatile Warburg Available



Model UV shown above, is a compact, circular unit, only 20½" diameter, 31" high, rotatable thru 320° permitting any of the manometers to be quickly read. Model UVL equipped for photo-chemical work.

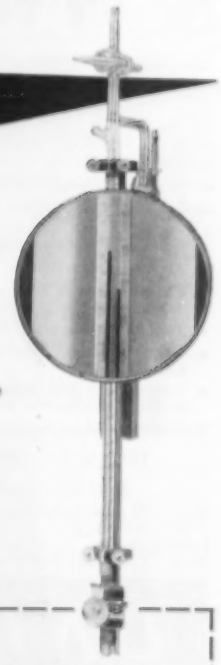
Requires only 20½" of Desk Space

- Magnetic Temperature Setting.
- Highest Temperature Constancy ±0.01° C.
- Cooling Coil Built In.
- Fastest to Set Up. Small bath (only 8 liters) heats from ambient to 37°C in 22 minutes.
- Rotatable thru 320°.
- Calibrated—Interchangeable Manometers & Vessels Available.
- Available for Photosynthesis.

EASY TO READ

DOUBLE CAPILLARY MANOMETERS

Single background scale—a sturdy single rod containing two capillaries. Available pre-calibrated—interchangeable—no more calibrating each time a piece is broken.



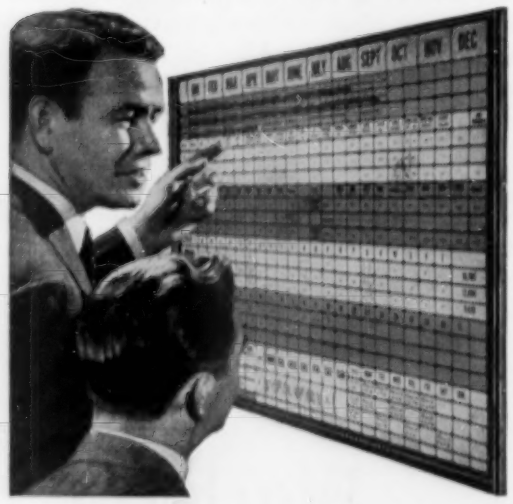
**The trademark identifying products of Bronwill Scientific Division, Will Corporation.*

BRONWILL
SCIENTIFIC DIVISION
WILL CORPORATION
131 GOULD STREET
ROCHESTER, N. Y.

BRONWILL SCIENTIFIC DIVISION
WILL CORPORATION
Box 127, Brighton Station, Rochester 10, N. Y., Dept. 685
Please send full information on Bronwill Warburgs.

Name.....
Position.....
Company.....
Address.....
City..... Zone..... State.....

You Get Things Done With Boardmaster Visual Control



★ Gives Graphic Picture of Your Operations —Spotlighted by Color
★ Facts at a glance—Saves Time, Saves Money, Prevents Errors
★ Simple to operate—Type or Write on Cards, Snap in Grooves
★ Ideal for Production, Traffic, Inventory, Scheduling, Sales, Etc.
★ Made of Metal. Compact and Attractive. Over 250,000 in Use

Complete price $49.50 including cards

FREE 24-PAGE BOOKLET NO. BF-20 Without Obligation

Write for Your Copy Today
GRAPHIC SYSTEMS
55 West 42nd St. • New York 36, N.Y.

STEREOSCOPIC MICROSCOPE
for the budget-minded!

Designed and sturdily built for educational or industrial use, UNITRON Model MSL has the same optical and mechanical features found in higher priced instruments.

- Erect, three-dimensional image
- Coated optics and prisms
- Achromatic 2X paired objectives, paired wide field eyepieces
- Working distance 75mm.
- Vertical binocular body with interpupillary and diopter adjustments
- Total focusing excursion 70mm.
- Heavy base, removable glass stage plate, stage clips
- Choice of one magnification 10X, 20X or 30X, extra eyepieces available

Complete in fitted hardwood cabinet ....

$110.00 FOB Boston

FREE 10 DAY TRIAL

ALSO AVAILABLE

Model MSL-A with magnifications — 5X or 10X or 15X $120.00
Extra eyepieces ..... Pair $10.50
Model LS Stereoscopic Microscope Lamp $14.75

UNITRON
INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASS.

Please rush to me, UNITRON's Microscope Catalog. S 2b
Name _____
Company _____
Street _____
City _____ State _____

that there is in fact a dichotomy between youth's images and aspirations. It fails to show that the image is substantially inaccurate (say, more inaccurate than the image held of other professions and trades). Nor is there anything in the data that would lead one logically to adopt the recommendations, some of which are simple good sense and others of which I regard as potentially disastrous for the position of science in our society.

The basic approach of the study to the problem of attracting youth to science is framed in terms of "how can we make science appear appealing to youth?" The proper questions, I submit, are, "How can we get across to youth an accurate image of science?" and "How can we evoke in a sufficient number of youths a personal identification with the admittedly prevalent positive image of science?" If it comes to changing science or changing youth, I'm for changing youth. Mead and Métraux do not appear to have considered the latter possibility.

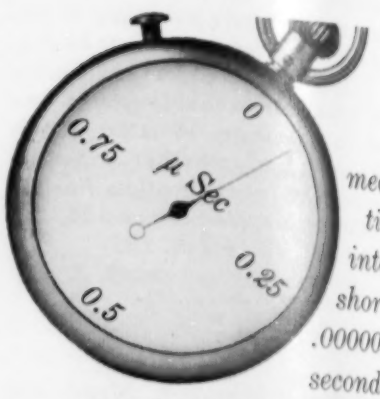
SANDER RUBIN
International Business Machines Corporation, Poughkeepsie, New York

In his letter discussing "The Image of the Scientist among High-School Students" [*Science* **126**, 384 (1957)], Sander Rubin raises a question about "a dichotomy between youth's images and aspirations," and also expresses doubt about the relevance of the conclusion that "when the question becomes one of personal contact with science as a career choice or one involving the choice of a husband, the image is overwhelmingly negative." It is his suggestion that the circumstance that the three questions asked of the high-school students were differently phrased—so as to elicit different kinds of response—"might be sufficient to account for differences in the responses."

It is the congruence in the answers to the questions, whether neutrally, positively, or negatively phrased, that supports the conclusion as stated. In his question about "images" and "aspirations"—if in this Rubin is referring to the students' image of the scientist and their image of their own desired futures—he has hit upon one of the major issues —namely, the divergence between the high-school students' picture of what a scientist's life must be and their picture of what they would like their own futures to be. This divergence was also clearly documented in the responses of the students. In our discussion, the focus was upon the image of the scientist rather than upon the students' aspirations.

An illustration based on one general point in the answers may serve to clarify the question.

The scientist, in answers to any one



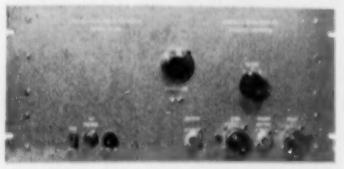
measure time intervals short as .0000000001 seconds

Milli-Microsecond
time-to-pulse-height converter

Model TH-300... Applications: Neutron time-of-flight studies, half-life determinations in short-lived isotopes, fast coincidence studies, short-time decay in isomeric states.
Domestic price **$795**. FOB, Factory.

Write for technical data sheet **Dept. S-2**

Eldorado Electronics



2821 Tenth Street
Berkeley 10, California

ADVANCES IN EXPERIMENTAL CARIES RESEARCH
AAAS SYMPOSIUM VOLUME
June 1955

246 pp., 6" x 9", 49 illus., index, clothbound

Price $6.75; cash order price for AAAS members **$5.75**

". . . This is a real contribution to dental science. It is the most comprehensive review of animal experimentation on caries ever attempted. The format and reproduction of illustrations are excellent.

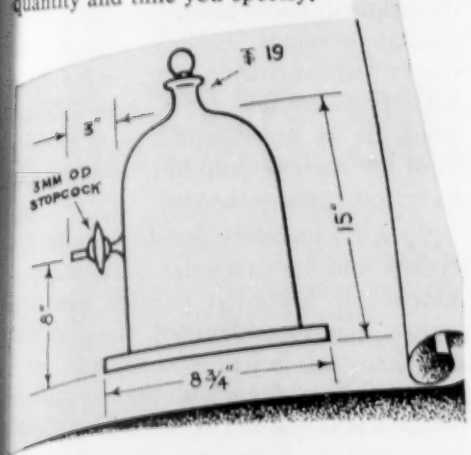
"This compilation of research findings should have wide circulation and should be a storehouse of information for all those who are investigating the problem of dental caries. It should serve to clarify the thinking and prevent useless duplication in future studies. . . ."

Russell W. Bunting, School of Dentistry, University of Michigan.

AAAS, 1515 Mass. Ave., NW, Washington 5, D.C.

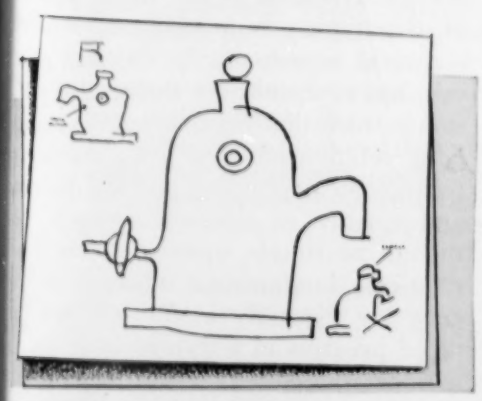
Pfiff

Bell jars with holes in them are of course special, but not so special that we cannot list them (and thousands of other special designs) in the Custom-Made Section of our new Catalog LG-1 for delivery in the quantity and time you specify.



So-So

Adding another passage here or there to a bell jar is a simple matter to the men in our Special Apparatus Department who, for over 30 years, have fashioned glass apparatus to customer specifications.



Merveilleux

Now a truly unique design such as this excites the hearts of our lampworkers. Nothing you can devise is too much of a challenge to their skills. Even a rough sketch sets them to blowing and bending glass to your will.

The over 9,000 different pieces of PYREX *apparatus in our catalog should satisfy 99% of your needs. When they don't, send us a sketch of what you want and we'll make it special.*

Special Apparatus Section
CORNING GLASS WORKS
34-2 Crystal Street, Corning, New York
Corning means research in Glass

of the three questions, is described as someone who works for very long hours in his laboratory and/or as someone who may have to travel to distant places. In describing the kind of scientist they would like to be or to marry (question II), students then describe one who "keeps regular hours" and who "has time for his family," and so on. In describing the kind of scientist they would *not* like to be or to marry (question III), the students write about the kind who is "always in his laboratory," who "has to travel," or who "has no time for his family." Thus, the "positive" and "negative" questions elicit responses which are congruent with each other and refer to a characteristic of the life of the scientist (as visualized by the students) which occurs in all phrasings of the question, but both responses indicate divergence from the picture they have of their own future, for only if, for example, the scientist—who works long hours—could work "regular hours" would science be a desirable career. Thus, however the question is phrased, the response is negative from the point of view of career choice.

MARGARET MEAD
American Museum of Natural History, New York, New York

RHODA MÉTRAUX
Cornell Medical College New York, New York

Soviet Support of Science

For a considerable period of time now the comings and goings of Sputnik have dominated the news. Their implications were discussed in a recent editorial in *Science* [**126**, 803 (1957)]. Although the Russian achievement has caused great surprise all over the world, American scientists and officials have properly noted that the U.S. satellite program will shortly be in a position to close this gap in scientific accomplishment. However, there is a much more serious implication to the Russian satellite which has received little attention. And that is the question of how Russian science has been able to produce, in quick succession, hydrogen bombs and atomic plants, jet transports and super jet bombers, as well as the intercontinental ballistic missile and the satellite.

It is perhaps obvious to say that these accomplishments are not mere coincidence but instead reflect the support given science and science education in the U.S.S.R. It is this program of support which is the important reality behind the spectacular break-through of Sputnik, for since its inception the Soviet government has regarded the training of scientific and technological personnel as its *key problem*. The Russian solution

RONALD Books

INTRODUCTORY PLANT SCIENCE

HENRY T. NORTHEN
University of Wyoming

SECOND EDITION! March 14. This highly praised elementary textbook has been revised and expanded to cover important new developments in plant physiology, including the results of radioisotope experiments in photosynthesis and salient features of new growth substances such as gibberellic acid. Additional emphasis is given to life cycles, reproductive processes and their biological significance, and the evolutionary and historic importance of groups of organisms. *401 ills., tables; 650 pp.* $6.75

FOREST SOILS

Their Properties and Relation to Silviculture

S. A. WILDE
University of Wisconsin

JUST PUBLISHED! An authoritative interpretation of the theoretical and practical relationships between good forest management and soil properties. The soil is considered as a major implement of silviculture which can increase timber output and diminish operational costs if skillfully utilized. Covers: maintenance of soil fertility, correction of various toxic effects, selection of suitable planting sites, etc. *216 ills., tables; 537 pp.* $8.50

The Physiology of FOREST TREES

Edited by **KENNETH V. THIMANN**
Harvard University

March 31. Compilation of the papers presented at the First International Symposium on Forest Tree Physiology by 33 authorities. Topics discussed include the ascent of sap, aspects of translocation, photosynthesis, the biochemistry of bark and wood, the growth of roots and shoots, photoperiodic response, etc. Also included are the stimulating discussions elicited by these papers. An invaluable contribution to a neglected field. *267 ills., tables; 607 pp.* $12

The Origin, Variation, Immunity, and Breeding of

Cultivated Plants

N. I. VAVILOV

The more important studies and essays by the eminent Russian scientist, translated by K. Starr Chester. Book covers genetics, breeding, variation, immunity, systematics, and evolution of plants. Includes a bibliography of basic literature on breeding and genetics of wheat. Chronica Botanica: An International Series of Biological and Agricultural Books. *37 ills., 364 pp.* $7.50

Order your books from:

THE RONALD PRESS COMPANY
15 East 26th St., New York 10

for this problem is based on the following:

1) The government subsidizes completely the training and education of scientists. The more capable the student is, the greater the subsidy given him. As a result, scientists are now being trained at a rate four times our own rate, and the U.S.S.R. will shortly have greater resources of technical personnel than the rest of the world combined. [C. E. Simmonds, *Technical Education in the U.S.S.R.* (Society for Cultural Relations with the U.S.S.R., London, 1957)].

2) The salaries for scientists are in the highest income brackets. The discoverers and purveyors of knowledge (such as the knowledge that made Sputnik successful) receive higher pay than the directors of the factories in which this knowledge is applied. For example, the director of a Metallurgical Institute may receive $200 per month more than the directors of the factories served by the institute, while a professor in the same institute can receive a greater salary than the chief engineer at the plant. ["Report of the Delegation of British Engineers," *Publs. Inst. Mech. Engrs.* (London, 1957)].

3) There is no stint on the provision of permanent research facilities free from the threat of curtailment with each new budget. Consequently, established scientists do not need to seek administrative posts in order to guarantee family security, while capable young scientists are not plagued by the uncertainty of temporary positions and curtailed funds.

4) Research institutes seem to be provided with 5-year budgets, improving continuity and freeing creative effort from the drain of yearly renewals and reports. The impact of this increased stability on the fundamental program is, of course, obvious.

5) Research arrangements are directed toward reducing the useless work performed by scientists and increasing the application of brain power to fundamental problems. Technicians and laboratory assistants trained at the B.S. level and specialized in laboratory skills are available in large numbers; it is common for each responsible investigator to have four such assistants.

6) Last but very far from least, scientists and in particular academic personnel are accorded prestige second to none. The president of the U.S.S.R. Academy of Sciences is regarded as a national hero along with the top political leaders and leading artists, with all levels of scientific personnel receiving commensurate recognition.

In the light of these considerations, the Sputnik is hardly to be viewed as a spectacular break-through but rather as an early harvest of unlimited support for science. Needless to say, future harvests of this type can quickly end Western technical supremacy. In the final analysis, however, it is not the relative position as such that matters, but the underlying relation between living standards, technological progress, and the quantity and quality of scientific research. Although no simple equation covers these relations, fundamental advances in science are certainly a *sine qua non* for rapid progress in a technological age. A national policy which fails to recognize this can result only in a population ideologically unprepared for the accelerated impact of technology and, therefore, incapable of developing adequate resources of creative power.

Irrespective of how little one may like the Soviet political system, and without in any way proposing that this country duplicate the Russian approach to the relationship of science and society, the major challenge of bold steps in this direction must be met by purposeful planning, beginning now.

R. J. RUTMAN

John Harrison Laboratory of Chemistry, University of Pennsylvania, Philadelphia

4 MORE RUSSIAN JOURNALS
NOW IN ENGLISH TRANSLATION

DOKLADY SECTIONS
PHYSICAL CHEMISTRY, BIOCHEMISTRY
GEOLOGICAL SCIENCES, APPLIED PHYSICS

IMMEDIATELY AVAILABLE —
SUBSCRIPTIONS BEGIN WITH THE 1957 VOLUMES

Doklady (Proceedings of the Academy of Sciences of the USSR) contains concise reports by leading Soviet scientists. It offers a comprehensive survey of the most advanced Soviet research.

Physical Chemistry—Approx. 500 pages per year. Includes all reports on chemical kinetics, interface phenomena, electrochemistry, absorption spectra, and related subjects.
Single issues, $35.00 — 6 issues per year, $160.00

Biochemistry—Approx. 150 pages per year. Covers plant and animal biochemistry.
Single issues, $15.00 — 6 issues per year, $65.00

Geological Sciences—Approx. 750 pages per year. Covers geology, hydrogeology, mineralogy, petrography, and geophysics.
Single issues, $40.00 — 6 issues per year, $200.00

Applied Physics—Approx. 600 pages per year. Includes all reports on crystallography, electrotechnics, hydraulics, hydromechanics, mechanics, theory of elasticity, and related subjects.
Single issues, $40.00 — 6 issues per year, $200.00

Individual articles are $5.00 each — Tables of Contents on request

Cover-to-cover translations by **bilingual scientists,** including all diagrams, photographs, and tabular material. Journals are staple bound in durable paper covers; clear multilith reproduction from IBM "cold type." Doklady is published in 36 issues annually—Consultants Bureau's English translation is published in 6. Issues are mailed to subscribers immediately upon publication.

For free catalogs of our current Russian translations, including 28 Soviet journals, write to Dept. S, specifying field of interest.

CONSULTANTS BUREAU, INC.
227 WEST 17th STREET, NEW YORK 11, N. Y. — U.S.A.
Telephone: ALgonquin 5-0713 • Cable Address: CONBUREAU, NEW YORK

TOO MANY VARIABLES?

It's time to draw a line.
Straighten out your cleaning problems with

HAEMO-SOL

There's nothing like Haemo-Sol's unique cleansing power and positive rinsing . . . it's completely safe! No etching! No corroding of metal parts! Immediate Haemo-Sol bath for valuable volumetric and optical equipment prevents soil etching!

Haemo-Sol guarantees clean laboratory glassware and apparatus—

- **removes the full range of laboratory soils**
- **effectively digests protenoid materials . . . other types of polymeric materials**
- **assures free draining pipets . . . burets**
- **gives sparkling clear surfaces for quartz and glass absorption cells**
- **provides chemically clean reaction and titration flasks**
- **leaves the clean surfaces that are a must for the smooth operation of fractionating columns and other pieces of laboratory equipment.**

And, just as important as its unique cleaning power, is Haemo-Sol's *high solubility* and powerful solubilizing action. Haemo-Sol washed glassware *rinses completely clean . . . nothing remains behind* but a chemically clean, free draining glass surface.

Write TODAY for Sample and Literature.

Distributed by

MEINECKE & CO., INC.

233 Varick Street
New York 14

EQUIPMENT NEWS

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to* Science, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

■ DYNAMIC ACCELEROMETER operates from 3 cy/sec to 60 kcy/sec with response ±6 percent between 5 cy/sec and 40 kcy/sec. Acceleration range is 0.01 to 1000 *g*. Transverse response is within 5 percent. The transducer operates on an electrokinetic principle. A polar liquid, when forced through a porous substance, creates an electric potential across the substance. The response is free from natural resonances. Shocks of 5000 *g* leave the instrument undamaged. (Consolidated Electrodynamics Corp., Dept. S879)

■ ELECTROMAGNETIC FLOWMETER overcomes the requirement for constancy of magnetic field by utilizing a reference voltage proportional to the magnetic field. Comparison of the reference signal with the voltage induced in the flowing liquid provides an actuating signal for operating an indicating servo. Unobstructed-bore metering sections range in diameter from ½ to 8 in. Full-scale range is manually adjustable. Accuracy for flows 0 to 3 ft/sec and above is ±1 percent. (Fischer and Porter, Dept. S880)

■ CRYSTAL OVEN uses proportional control to maintain temperature constant to 0.1 percent of ambient-temperature change. A temperature-sensitive resistance bridge is used for both heating and temperature sensing. The control point can be preset at any temperature between 10° and 100°C above ambient. An accessory one-tube oscillator controlled by the thermostatted crystal furnishes a 1 Mcy/sec signal stable to ±1 part in 10^8 per day. (Manson Laboratories Inc., Dept. S895)

■ ELECTRONIC TACHOMETER measures rotational speeds from 0.1 to 10,000 rev/min. Radial lines scribed on a rotating disc interrupt a light beam in the transducer, producing 360 pulses/rev. The pulse rate is indicated on a meter. (Southwestern Industrial Electronics Co., Dept. S896)

■ AUTOMATIC FILM PROCESSOR develops and dries 16-mm film at the rate of up to 10 ft/min. The processor, about the size of a standard file drawer, will handle film lengths from 1 ft to 400 ft without changing or replenishing chemical solutions. After insertion of the first 2 in. in a slot, the film travels automatically through a series of chemical baths.

for Modern LABORATORY EFFICIENCY *the New*

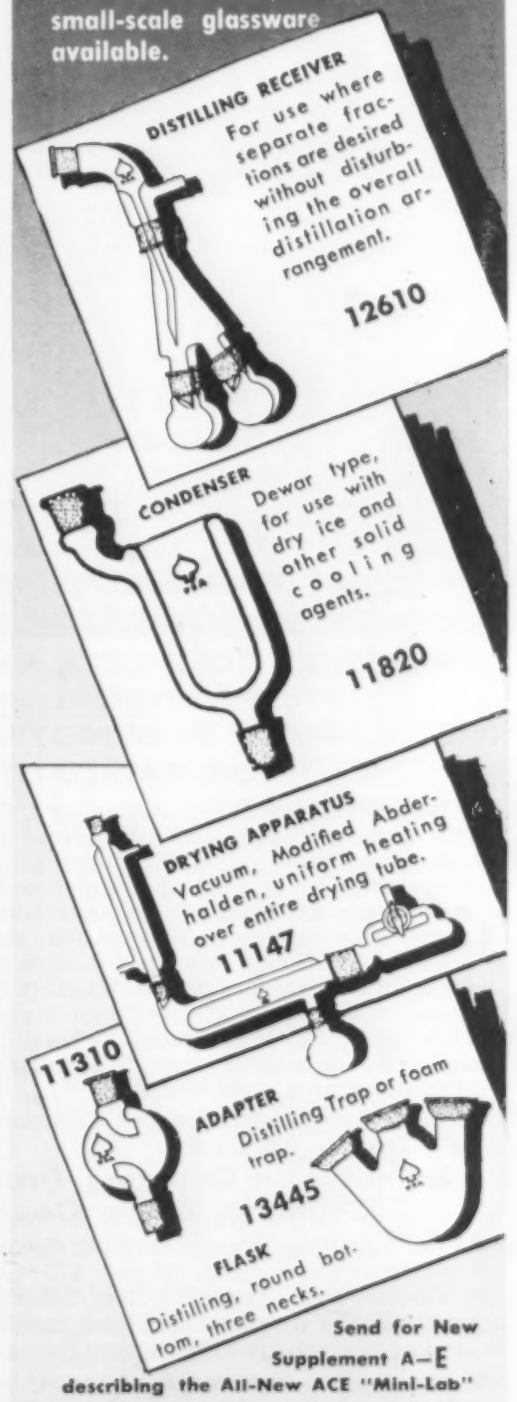
ACE "MINI-LAB"

SAVES TIME—SPACE—MONEY

Originally introduced by Ace in 1950 with ⅀ 14/35 joints.

Additional assemblies and components added in 1954, and joints converted to ⅀ 14/20 size.

Now, in 1957, Ace makes another advancement with many new components, and many items equipped with ⅀18/19 joints; truly the most versatile line of small-scale glassware available.



Send for New Supplement A—E describing the All-New ACE "Mini-Lab"

Also in stock at our Midwestern Division, Louisville, Ky., Box 996.

ACE GLASS INCORPORATED
VINELAND ♠ NEW JERSEY
Midwestern Division
LOUISVILLE, KY.—Box 996
Specialists to Industry and Research

After leaving the last tank, it enters a drying compartment; when it emerges, it is wound on a roller ready for projection. (Fairchild Camera and Instrument Corp., Dept. S898)

■ COLORIMETRIC TITRATION KIT, for installation in the manufacturer's electronic colorimeter, permits colorimetric titrations to be carried out directly in the instrument. The kit consists of a magnetic stirrer for sample stirring and a hinged lid assembly for introducing a burrette into the cell compartment. (Fisher Scientific Co., Dept. S909)

■ THERMAL RIBBON consists of a resistance element of high-nickel-content alloy wire encased in a flexible outer covering. Less than 0.02 in. thick, the ribbon may be cemented to surfaces to permit detection of surface temperature. Thermal lag is said to be negligible. Self-adhering types are available. (Minco Products, Inc., Dept. S904)

■ INFRARED HEATER of quartz is available in lengths up to 72 in. and in wattages to 6000. Peak emission of infrared radiation occurs at a wavelength of 2.3 μ. (Quartz Products Corp., Dept. S912)

A new ADVANCED RADIOACTIVITY ANALYSIS LABORATORY

Baird-Atomic University Series ADVANCED LABORATORY

PROVIDING COMPLETE SYSTEMS FOR SCINTILLATION, PROPORTIONAL and GEIGER COUNTING
THE ULTIMATE IN SENSITIVITY, RELIABILITY AND SPEED FOR RADIOACTIVITY ANALYSES

The B-A University Series Advanced Laboratory is completely new in design and capabilities and is the most complete and most versatile radioactivity analysis laboratory available in the field of research today. It is capable of performing all types of gas and scintillation counting of alpha, beta, gamma and x-rays with ease and precision. The University Series Advanced Laboratory is completely versatile in that three different detectors can be used with the same fundamental system. With these three detectors, the laboratory has the capacity to handle the most highly specialized radioactivity analysis problems encountered in industrial research applications.

The University Series Advanced Laboratory is also available in separate systems for:

Scintillation Counting, Proportional Counting, Geiger Counting

Add the following accessories to provide complete facilities for all researchers: B-A Model 410 Count Rate Meter and Geiger Tube, the 1225 Beta Sources, 1230 Gamma Sources, LC2 Carrying Case, and the Model 414 Single Scale Logarithmic Gun type survey meter.

See our Atomic Instruments at the Atomic Exposition & Nuclear Congress — March 17-21, Chicago, Illinois.

FEATURES

- 1 MICROSECOND RESOLVING TIME
- BUILT-IN AMPLIFIER WITH SENSITIVITY OF 1 MV
- SEPARATE SUPER-STABLE HV POWER SUPPLY (5000 V. optional)
- ELECTRONIC TIMER
- 6-DECADE COUNTING CAPACITY, ALL ELECTRONIC
- PREMIUM COMPONENTS FOR RELIABILITY

Baird-Atomic, Inc.

33 UNIVERSITY RD., CAMBRIDGE 38, MASS.

Baird Atomic

Instrumentation for Better Analysis

■ ELECTRONIC INTEGRATOR accepts analog voltage signals, digitizes them by a heterodyne technique, and integrates the area under the signal curve by counting at the rate of 10,000 counts per second. The integral can be the total area under the curve, the area above a preselected signal level, or the area under the curve between selected limits. Both the integral and the elapsed time are displayed digitally. (Allegany Instrument Co., Inc., Dept. S897)

■ SCALER-RATEMETER features a wide choice of slide-out plug-in sections that allow the instrument to be assembled to fit specific needs. Maintenance requires only replacement of faulty units with quickly available modular units. Units include amplifiers for various inputs, binary and decade scales, electromechanical registers, timers, power supplies, ratemeter, chassis, and cabinets. (Nucleonic Corporation of America, Dept. S899)

■ RECORDER provides up to 8 full-scale, 11-inch traces with ± 1 percent accuracy and transient response up to 3000 cy/sec. The record is made on electrosensitive paper which passes between a metal plate and a rotating cylinder carrying a number of helical electrodes. Pulses are applied to the helix at the moment its position with respect to the paper is correct for the signal magnitude being recorded. Paper motion provides the other coordinate. Calibration marks are recorded simultaneously with input signals. Time markers are provided at 1-, 0.1- or 0.0167-sec intervals. Individual channel traces may be coded for identification by varying the width and darkness of traces. (Consolidated Avionics Corp., Dept. S900)

■ TIME COUNTERS are designed to count at rates specifically matched to the rate of heating specified by particular ASTM tests. The counters therefore indicate at all times the temperature which should exist in the conduct of the test. The task of maintaining the prescribed constant rate of increase of temperature thereby reduces to equating the temperature reading to the indicated count. (Apex Scientific Co., Dept. S902)

■ TISSUE HOMOGENIZERS operate hydraulically to permit controlled release of cellular components from various tissues. Complete disruption of nuclei can also be accomplished. Tissue fragments, suspended in buffer, are introduced into the cylinder of the device and are ejected at high velocity through an orifice by a piston. The orifice opening can be varied. (Microchemical Specialties Co., Dept. S903)

JOSHUA STERN
National Bureau of Standards

COLLEGE PHYSICAL SCIENCES

by WENDELL SLABAUGH, Oregon State College, and ALFRED B. BUTLER, State College of Washington

This new text features an unusually complete integration of the four basic areas of physical science. This integration is based upon the successive treatment of mechanical, electrical, chemical, heat and nuclear energy, followed by an immediate application of the fundamentals of these forms of energy to geology, astronomy, meteorology and other areas in physical science. A firm understanding of the basic principles and methods which have the greatest importance to the student is provided and accordingly there is a maximum of correlation throughout of the various areas of physical science. The problems are thought provoking and entice the student to consider other, original, applications of the principle.

576 pp. • Pub. March, 1958 • Text price $7.95

To receive approval copy promptly, write: Box 903

PRENTICE-HALL, Inc.
Englewood Cliffs, New Jersey

Specify

DIFCO *. . . the only complete line of microbiological reagents and media*

Culture Media
Microbiological Assay Media
Tissue Culture and Virus Media
Serological Reagents Antisera
Diagnostic Reagents
Sensitivity Disks Unidisks
Peptones Hydrolysates Amino Acids
Enzymes Enrichments Dyes Indicators
Carbohydrates Biochemicals

•

60 years' experience in the preparation of Difco products assures
UNIFORMITY STABILITY ECONOMY

•

Complete Stocks Fast Service 24-hour Shipment

•

Difco Manual and other descriptive literature available on request

DIFCO LABORATORIES
DETROIT 1, MICHIGAN

From the new Sigma Reagent Catalog, we offer AMINO ACIDS

This is one of a series of advertisements which will cover the entire catalog. A complete copy is available on request. Other package sizes shown in complete catalog.

N-ACETYL-DL-ALANINE (pfs)	100 grams	8.90
N-ACETYL-DL-LEUCINE (pfs)	100 grams	8.90
N-ACETYL-DL-METHIONINE (pfs)	100 grams	2.25
N-ACETYL-DL-TRYPTOPHANE (pfs)	100 grams	29.00
N-ACETYL-DL-VALINE (pfs)	100 grams	9.75
β-ALANINE (pfs)	100 grams	2.10
DL-ALANINE (pfs)	100 grams	3.40
L-ALANINE, Sigma Grade (pfs)	25 grams	27.50
D-ALANINE, Sigma Grade (pfs)	25 grams	47.00
DL-α-AMINO BUTYRIC ACID (pfs)	25 grams	1.95
α-AMINO ISOBUTYRIC ACID (pfs)	100 grams	7.75
δ-AMINO LEVULINIC ACID (pfs)	100 mg	17.50
L-ARGININE HCl, Sigma Grade (pfs)	100 grams	13.50
DL-ASPARTIC ACID (pfs)	100 grams	4.00
L-ASPARTIC ACID, Sigma Grade (pfs)	25 grams	8.50
L-CYSTEINE HCl hydrate (pfs)	100 grams	7.00
DL-β-(3,4-DIHYDROXYPHENYL ALANINE) (DOPA) (pfs)	25 grams	13.75
L-β-(3,4-DIHYDROXYPHENYL ALANINE) (DOPA) (pfs)	1 gram	7.90
D-β-(3,4-DIHYDROXYPHENYL ALANINE) (DOPA) . . (pfs) (When available)	1 gram	9.50
3,5-DIIODO-L-THYRONINE (pfs)	500 mg	14.00
3,5-DIIODO-L-TYROSINE, Sigma Grade (pfs)	25 grams	2.65
3,5-DINITRO-L-TYROSINE (pfs)	5 grams	12.50
DL-ETHIONINE (pfs)	100 grams	11.50
L-ETHIONINE, Sigma Grade (pfs)	1 gram	4.70
D-ETHIONINE, Sigma Grade (pfs)	1 gram	4.70
L-GLUTAMIC ACID (pfs)	500 grams	5.25
GLYCINE (Aminoacetic Acid) (pfs)	500 grams	4.00
GLYCYL-GLYCINE or HCl	10 grams	4.50
L-ISOLEUCINE (with D-Allo) Microbiological Assay 47-53% (pfs)	100 grams	12.90
L-ISOLEUCINE (Allo-free), Sigma Grade (pfs)	5 grams	7.00
D-ISOLEUCINE (pfs) When available	500 mg	12.00
DL-KYNURENINE Sulfate (pfs)	1 gram	14.00
DL-LEUCINE (pfs)	100 grams	5.40
L-LEUCINE (pfs)	100 grams	4.95
DL-LYSINE HCl (pfs)	100 grams	10.00
L-LYSINE HCl (pfs)	100 grams	8.50
DL-METHIONINE (NF) (pfs)	500 grams	8.50
D-METHIONINE, Sigma Grade (pfs)	5 grams	5.70
L-METHIONINE, Sigma Grade (pfs)	25 grams	11.00
DL-PHENYLALANINE (pfs)	100 grams	11.00
D-PHENYLALANINE, Sigma Grade (pfs)	5 grams	11.50
L-PHENYLALANINE, Sigma Grade (pfs)	10 grams	10.00
DL-PROLINE, Sigma Grade (pfs)	5 grams	15.75
L-PROLINE, Sigma Grade (pfs)	25 grams	14.00
DL-SERINE (pfs)	100 grams	12.50
D-SERINE, Sigma Grade (pfs)	1 gram	7.95
L-SERINE, Sigma Grade (pfs)	1 gram	5.75
SARCOSINE HCl, Sigma Grade (pfs)	25 grams	12.50
THREONINE (pfs)		Inquire
L-THREONINE (pfs)	5 grams	15.00
DL-TRYPTOPHANE (pfs)	25 grams	7.10
L-TYROSINE (pfs)	100 grams	3.30
DL-TYROSINE (pfs)	100 grams	5.75
DL-VALINE (pfs)	100 grams	6.00
L-VALINE, Sigma Grade (pfs)	5 grams	10.00
D-VALINE, Sigma Grade (pfs)	5 grams	10.50

TELEPHONE COLLECT from anywhere in the world
Day, *Station to Station* PRospect 1-5750
Night, *Person to Person* Dan Broida— WYdown 3-6418

SIGMA CHEMICAL COMPANY

3500 DeKalb Street — St. Louis 18, Mo., U.S.A.